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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

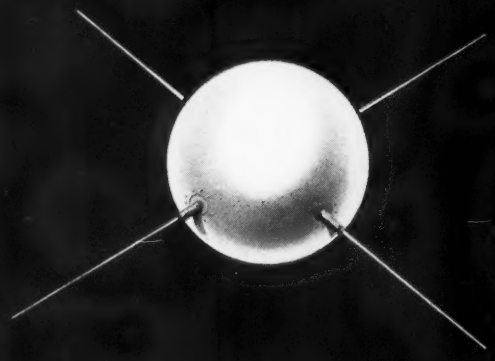
JULY 1958

Mel Hunter

SPECIAL SECTION
ON RESEARCH AND TESTING

National Space Program Takes Shape . . . . . Irwin Hersey
Supporting Research and Ballistic Missiles . . . . . Louis G. Dunn
The First Space Ship . . . . . Martin Caidin

VANGUARD!



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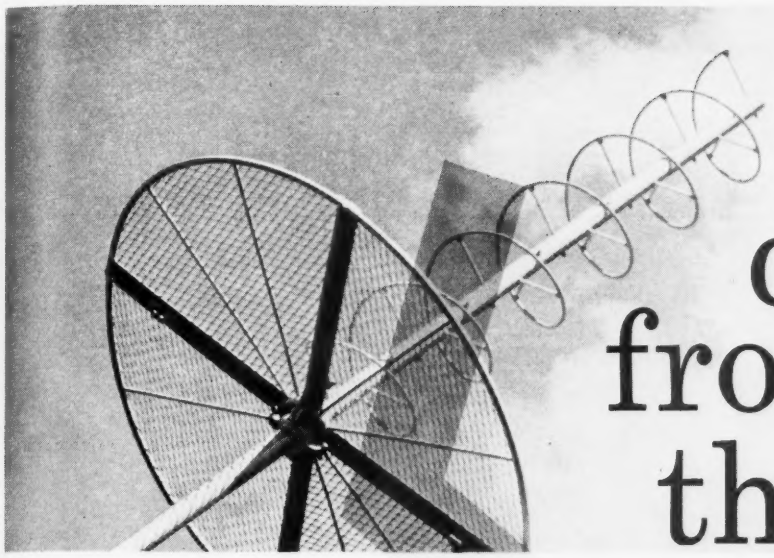

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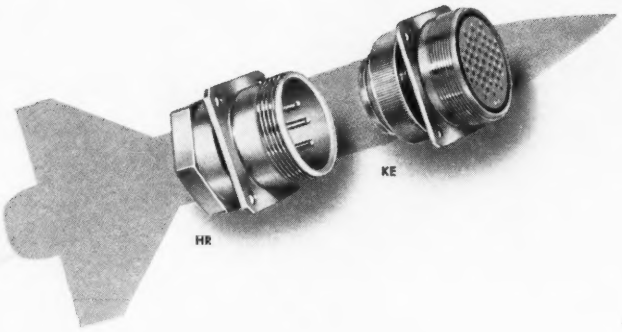

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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY, INC.

July 1958 volume 3 number 7

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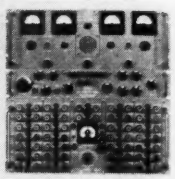

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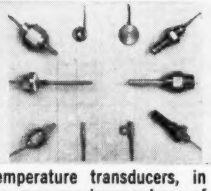

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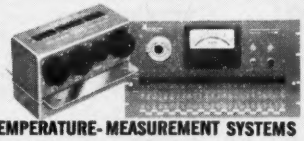
Resistance-type temperature transducers, in many configurations, measure temperatures of surfaces, fluids, air, electronic components, etc. Ranges cover −320°F to 2000°F; nominal resistance 100-20,000 ohms. High-resistance units give output without amplification of 0-5v. Bulletin 300.



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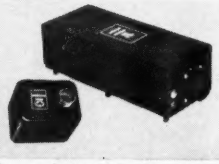
Airborne or rack-mounted subsystems use resistance-type transducers to measure temperatures in missiles, aircraft, rocket test stands, nuclear reactors, etc. Models using high-resistance transducers give 0-5v output without amplification for 150°F span. New transistorized models give 0-5v output for 75°F span with 100-ohm transducers. Models range from 1-25 channels capacity. Bulletin 500.



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Low-voltage series supply precision transducer excitation and reference voltage to instrumentation systems. Bulletin 101A.

Astro notes

LUNAR PROBES

• Premature announcement by Lt. Gen. S. E. Anderson, ARDC Commander, that Air Force would shoot for the moon next month, and again in September and October, brought quick denial from ARPA Chief Roy Johnson and an official reprimand for Anderson from AF Secretary James H. Douglas. Johnson noted that no decision had been made on dates for the moon firings and pointed out that ARPA would decide when the attempts would be made. Anderson's off-the-cuff statement aroused DOD fears of another propaganda buildup similar to that which marked the Vanguard program.

• Most appropriate dates for launching of moon rockets are those times of the month when the moon reaches the most northerly point of its orbit—about 18.5 deg. This will occur Aug. 10, Sept. 7 and Oct. 4 and 31. Actual launching would take place about two days before these dates to allow for transit time of the vehicles. Accurate timing would not reduce energy requirements, but might minimize guidance error and assure better radio tracking from U. S. stations.

MISSILES

• Army seems to have won another round in the long-standing Thor-Jupiter controversy with DOD announcement that Chrysler has been authorized to set up a production line for Jupiter. Pentagon was apparently swayed by recovery of Jupiter nose cone after 1600-mile flight in May.

• Aerojet brass deny difficulties in reaching sought for goal of I_{sp} of 240 for Polaris, say this target was reached some time ago.

• AF selection of contractors to build the solid-propellant Minuteman ICBM is expected next month. Ramo-Wooldridge still seems to be the AF choice to serve as "technical monitor" for the project, as it is now doing with the Thor, Atlas and Titan. Companies seeking Minuteman contracts aren't too happy about the arrangement, but see no way to avoid it.

• DOD has flashed green light for start of production within next two months of a million-lb thrust rocket engine. An initial $15 million has been allocated for the project, which will cost at least $200 million over next five years.

North American Aviation is convinced it has won the contract to develop the million-lb thrust engine. Its Rocketdyne Div. is currently developing a single-barrel unit of 300,000-lb thrust for the AF, as well as supplying the 150,000-lb thrust motors used in the Thor, Jupiter and Atlas missiles.

• First attempt to fire Atlas over its full 6000-mile range will be made next month.

• An alternate anti-missile missile project to Nike-Zeus is underway, according to recent testimony of DOD Secretary Neil H. McElroy during a House Appropriations Committee session.

• Army's award of Sergeant's airframe production to Sperry Gyroscope may presage trend toward letting prime contracts for future missile and space projects to electronics and powerplant producers.

• AF has announced development of a new atomic air-to-air missile, GAR-9, to be used on the F-108 interceptor which will fly at Mach 3.

• Russia is said to have flight tested a new rocket-propelled air-to-ground ballistic missile with megaton warhead and an approximate range of 50 miles, the equivalent of our Rascal.

SPACE AGENCY

• Senate and House representatives were busy hammering out a Space Agency bill which would meet approval of both branches of Congress at press time. Basic issues were how much of a voice DOD would have in policy determination and the role NASA would play in military space projects. Where the House bill provided for a 17-man board which would be largely advisory, the Senate bill would establish a seven-man executive Space Policy Board empowered to make decisions on all major space projects. Board would consist of Secretaries of Defense and State, NASA director, AEC chairman and three presidential appointees.

Meanwhile, delay in getting NASA underway was causing considerable concern both at the Pentagon and in existing space development agencies. ARPA chief scientist Herbert York has said the new agency would need at least half as much money as that voted ARPA for its first year of activity. And Wernher von Braun has warned that the agency may not get off the ground until the end of the year. "I personally feel that we cannot afford to wait until the agency is ready to go," he noted.

NUCLEAR POWER

• Administration has reversed its policy toward development of nuclear-powered rockets and asked Congress for a $200 million appropriation to step up and expand atomic propulsion R&D. Revitalized interest is attributed to Sputniks. The fund will be split 50–50 among Project Rover (atomic rocket development at Los Alamos Scientific Laboratory, N. M.) and Project Pluto (ramjet engine development at Livermore Laboratory, Calif.) . . . John A. McCone, certain to succeed Lewis L. Strauss as AEC chairman, is touted as staunch supporter of atomic missiles . . . AEC has asked Congress for $2.3 million for Project Snap, involving development of nuclear auxiliary power sources for satellites and space ships.

R&D

• General Electric, prime contractor for Atlas guidance, has come up with coded anti-jam filters which are said to reject interference and make the Atlas system virtually jam-proof.

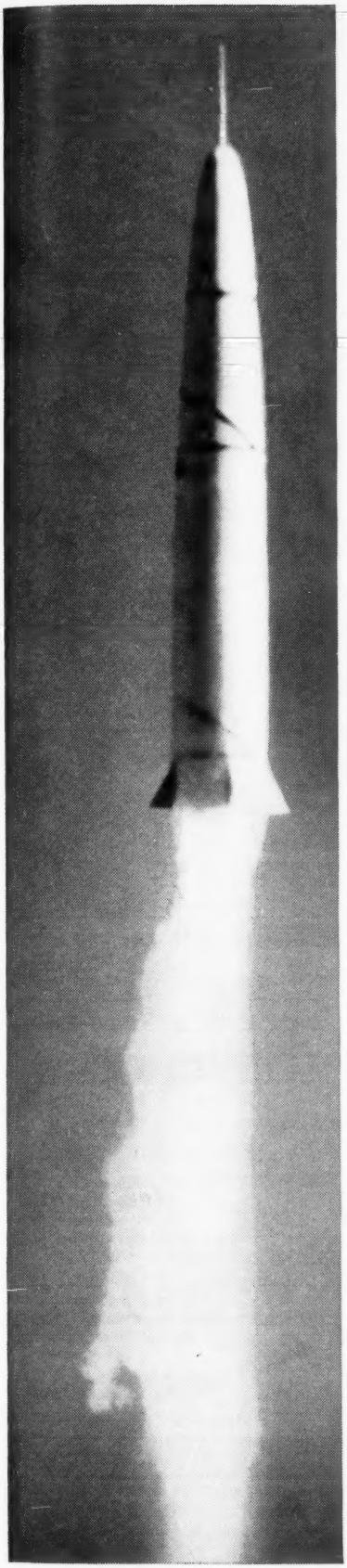
• Dyna-Soar contracts have been awarded to a Martin-Bell team and Boeing by the Air Force. Cost of developing the boost-glide vehicle has been estimated to be about $150 million. AF budget includes at least $5 million in fiscal 1959 research funds for the project, which represents the most ambitious U. S. step to date toward manned space flight . . . In the interim, AF is considering a weapon that is a cross between the Dyna-Soar and B-70, which will be capable of speeds up to 4000 mph at 100,000 ft altitude and below . . . A portable rocket which is strapped to a man's back and will enable him to run with the speed of a racehorse, "jump across rivers, scale walls and cliffs, and jump extraordinary heights," has been developed by a Reaction Motors engineer . . . At Aerojet-General, work is progressing on a self-propelled, plastic torpedo-shaped underwater atomic missile, code named SPU, that a Navy frogman could straddle and steer toward enemy submarines or shore installations. A robot mechanism takes over once the frogman has hopped off to safety . . . Grand Central Rocket Co. is reported hard at work on AF space projects involving use of very large solid-propellant engines.

IGY

• IGY National Committee has announced that 36 Hawk Rockoons, each consisting of a modified Loki II solid-propellant unit, were launched in the Atlantic, Pacific and Antarctic areas from Sept. 26 to Nov. 9, 1957, as part of the US-IGY program. Of the total, 20 were normal flights, reaching summit altitudes of 105–135 km; 7 did not fire; 2 performed erratically; and 7 were lost.

MATERIALS

• Super-tough, high-resistant plastics are challenging metal alloys and ceramics for prominent positions in missiles and rockets. The plastics are being heralded as the solution to re-entry problems inasmuch as they not only can withstand extremely high temperatures and erosion from meteoritic dust, but also offer a great weight advantage. Plastic proponents proudly point to the Army's successful recovery of a plastic Jupiter nose cone a few month ago.



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For the record

The month's news in review

May *1*—Initial data from Explorers I and III reveal an intense belt of radiation some 600 miles in space.

—Soviet scientists disclose that Laika's heartbeat rose to about three times its normal rate while Sputnik II was being accelerated into orbit.

—Roy W. Johnson, ARPA chief, urges Congress not to give NASA power to limit "military use of space."

May *2*—Herbert F. York, scientific director of ARPA, sees U.S. launching "returnable satellites" in 1959 or 1960 and a satellite weighing "several tons" in next few years.

—U.S. announces it will test fire short-range defensive missiles armed with nuclear warheads in forthcoming nuclear firings at Eniwetok.

May *5*—Pentagon cuts back production of Jupiter, giving preference to Thor.

May *6*—Navy sends two men up in a balloon from Crosby, Minn., to study stars and planets from 40,000 ft.

May *7*—Roy W. Johnson and Herbert F. York say President's proposed civilian space agency could place unnecessary restrictions on military space projects.

—AF fires Snark successfully.

May *8*—Secretary of Defense Neil McElroy points out that dual production of Thor and Jupiter has cost government $100 million.

—Navy expresses "grave misgivings" about proposed civilian space agency to House Space Committee.

—Polaris explodes shortly after take-off, but Navy says rocket behaved as expected.

—AF F-104A Starfighter climbs to record altitude of 91,249 ft.

May *14*—Navy successfully fires Regulus.

May *15*—3000-lb Sputnik III is fired into orbit by Soviet Union. Nose cone, two side shields and carrier rocket also orbit.

May *16*—Larger of two transmitters on Explorer III goes dead.

—AF F-104A Starfighter sets world speed record, averaging 1404.19 mph.

May *17*—Administration asks $20 million appropriation for nuclear rocket and ramjet facilities, and an undisclosed amount to expand R&D work in nuclear propulsion.

May *18*—Army recovers Jupiter nose cone in re-entry test.

May *19*—Dag Hammarskjold, UN Secretary-General, urges all nations to renounce territorial claims to outer space.

—House Space Committee okays bill for civilian space agency.

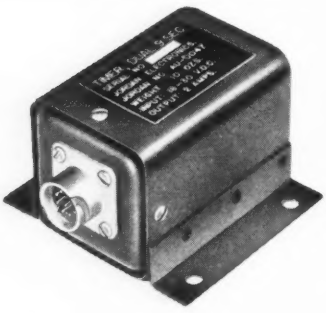
May *21*—Explorer III's radio comes back on after a week of silence.

May *26*—Navy F4D-1 Skyray sets five official world climbing speed marks.

May *27*—Navy fires 20-in. Vanguard.

May *28*—Navy announces Vanguard failed to orbit.

May *30*—AF reveals development of new air-to-air atomic missile, the Gar-9.



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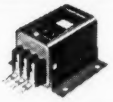

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NAVAHO	Transporter-erector and vertical access tower

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Capital wire

News highlights from Washington

SPACE WEAPONS

• Fascinating references to two new weapon systems cropped up in Pentagon appropriations testimony, but all discussion was carefully excised from the record. One was called "Project Argus," the other a "bomb-powered rocket." Argus was a Greek mythical giant with 100 eyes. This may hence refer to a satellite reconnaissance system utilizing the electromagnetic signature of rocket motor exhausts for early warning of Soviet ballistic missile activity.

• Look for preliminary tests of the AF WS-117L reconnaissance satellite this year, with the Thor-Vanguard combination used for launching. The satellite will weigh about 2500 lb (half batteries) and need an Atlas booster. AF committed $55 million to the system in fiscal 1958, another $152 million in fiscal '59. Toughest problem is not the satellite but developing machines to process the volume of data it will gather.

• Pentagon witnesses painted a gloomy picture of the decoy problem which an anti-ICBM will have to cope with to be even partially successful. Fragmentation of the rocket case or distribution of lightweight metal jacks could cover an area 100 times larger than the lethal volume of the anti-warhead, they noted. But, they added, high-speed computers might be developed to examine the forests of radar blips and reject as potential targets those decelerating more rapidly.

• The Pentagon got House Appropriation Committee approval for all the funds it sought for development of the Nike-Zeus anti-ICBM and related early warning equipment—some $343 million—despite a lack of enthusiasm on the part of Defense witnesses for the project.

LUNAR PROBES

• AF hopes to fire the first of its three Thor-Vanguard lunar probes in August, but September looks like a better date. Both of the Army's Jupiter-boosted probes will be fired this year. Payloads include magnetometers, mechanical TV scanners, possibly a Polaroid Land camera, and electronic relay system.

CIVILIAN SPACE AGENCY

• The House Space Committee approved a bill creating a powerful new civilian space agency to be called the National Aeronautics and Space Administration. It followed the Administration proposal that NACA be made the nucleus of the new space agency, but sought to give the NASA chief greater power over the military program than contemplated in the Administration bill.

In its report, the committee staff declared that the NASA director must be "supreme arbiter of astronautics policy" under the President and that conflicts with the military should be handled in the National Security Council.

Senate action on the space agency was expected to follow in a few weeks. Members of the Senate Space Committee reportedly favor the Administration plan of joint civilian-military authority over U.S. space projects, but would set up a powerful board over the NASA chief to create national space policy and allocate projects between the military and civilian agencies.

• NACA and ARPA have decided on a program of joint control over development of the "man-in-space" program and the 1-million lb thrust rocket motor. Relations are reportedly good at the working level, but it is understood that ARPA Director Roy Johnson has objected strenuously to pressure from the Budget Bureau to vest actual control of either project in NACA.

SATELLITES

• NACA's air density satellite experiment—the 12-ft aluminum sphere—has been postponed because of the eagerness of IGY officials to check the intense radiation uncovered in Explorer cosmic ray experiments. New equipment will consist of two geiger and two scintillation counters with 4000 times the range of the first Explorer counters.

• A Washington conference in May on the possibilities of life science experiments in satellites has focused sharp interest on animal experiments in space. The meeting, of which NAS was one of the sponsors, produced a large number of interesting papers, including many proposals for satellite experiments with rodents, simians, and other forms of life.

MILITARY BUDGET

• House Appropriations Committee put decisive new emphasis on missile weapon systems at the expense of manned aircraft in its vote to give DOD $38.3 billion in new money for the fiscal year beginning July 1. While the lawmakers voted $114 million more than the Administration requested, they made many changes within the bill to put more heat on missile programs.

Final Pentagon appropriation bill most likely will be toned down by the Senate, although House committee action is viewed sympathetically by other lawmakers. Defense Secretary McElroy has said, however, that he regards the House vote as an "authorization" and not a "command," with the implication that he may not release the additional funds for the projects voted by the group.

HEARINGS

• Veteran congressional observers were stunned recently when irascible Dan Flood, probably the most cantankerous congressman ever to sit on the House Appropriations Committee, came up with this compliment for Herbert York, 36-year-old ARPA chief scientist for the Pentagon's Advanced Research Projects Agency:

"Doctor, in the past year especially, and for the last four or five years more particularly, we have had a galaxy of scientific stars orbiting this committee and passing through the atmosphere of this room, the likes of which you would never believe. But you certainly impress me as being not only one of the most learned, but one of the most human, that I have seen, heard, or smelled."

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Sputnik III—Another Blow to U. S. Prestige

THE SOVIET UNION'S Sputnik III, a 2925.53-lb cone-shaped satellite described as a complete "flying laboratory" and successfully launched May 15, amid endless talk before Congressional committees on what type of space flight program the U.S. should have, was another healthy whack at dwindling American prestige in the rocketry-astronautics area.

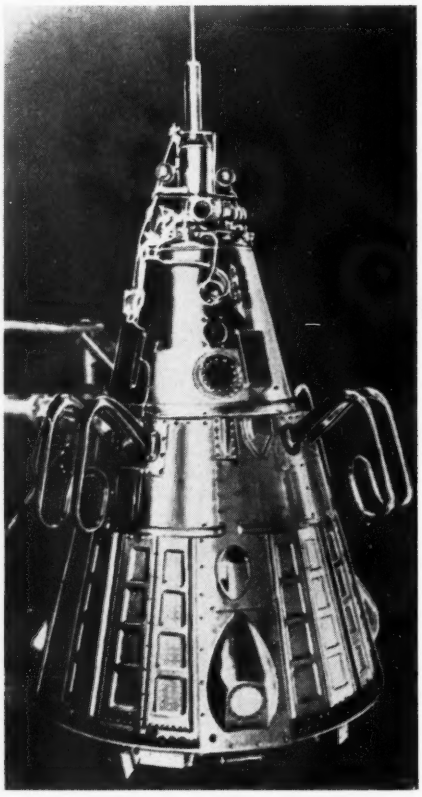
Rocket engineers and scientists in this country, visibly shocked at the size of the new "moon" and the brief Russian listing of the instrumentation it contained, commented that it would take the U.S. from two to three years to launch a satellite of the same size and scope. They speculated that thrust required to put the new Soviet satellite in orbit was at least 500,000 lb, and might have been even greater.

Of its total weight of almost $1^1/_2$ tons, 2129 lb represents full-sized instruments simultaneously carrying out a number of experiments in the fields of cosmic radiation, solar radiation, and micrometeorites, as well as studying conditions in the upper atmosphere and the earth's magnetic field. The payload carried in the satellite was almost as much as that of the combined instrumentation aboard all the satellites launched previously by both the U.S. and Russia.

The new Sputnik is about 68 in. diam at the base and 140 in. long. Its orbit is farther from the earth than those of Sputniks I and II, with an apogee of 1168 miles and a perigee of 150 miles. Large enough to be visible to the naked eye in good weather in some areas, the satellite is expected to have a lifetime of six months. In orbit with Sputnik III are the nose cone, two semi-cylindrical tapering side shields, and the carrier rocket that protected and launched the satellite.

Like the earlier Sputniks, it is in an orbit inclined 65 deg from the equatorial plane, and had an initial orbit time of 106 min. Radio signals are being broadcast at a rate of 150 to 300 millisec on a frequency of 20.005 mc. A single coordinating calculating center set up by the Russians will collate all findings from the satellite itself and individual observation points.

Components in Sputnik III fall into three major groups. The first includes apparatus to check cosmic rays, solar radiation, and the number and intensity of micrometeorites. A second group is designed to study conditions in the earth's atmosphere—composition, pressure, ionization, and electrical phenonema—as well as the earth's magnetic field. A third group is there to power and regulate the other instrumentation. This group includes solar batteries; heat-regulating system to keep the instruments from being affected by temperatures extreme; a program-control system to turn the instruments on and off; and a radio transmitter to transmit the data obtained.



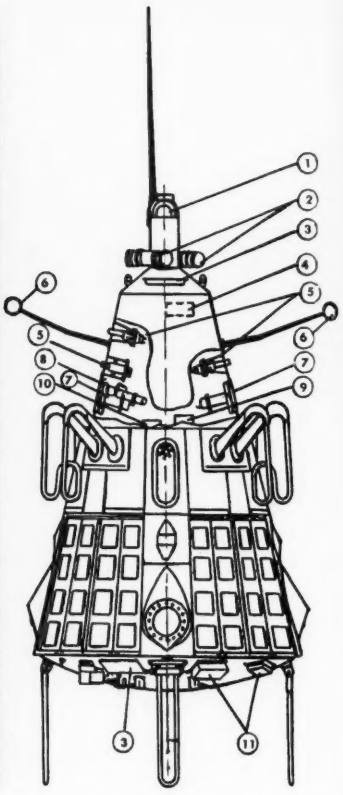


Photo and diagram of Sputnik III that appeared in Pravda show instrumentation aboard this "flying laboratory." Components include (1) magnetron; (2) photo multipliers to measure solar radiation; (3) solar batteries; (4) apparatus to register photons in cosmic rays; (5) manometers; (6) ionic traps; (7) electrostatic fluxmeter; (8) mass spectrometer tubes; (9) and (10) apparatus to register cosmic ray radiation; (11) micrometeor recorders.

Professor Yevgeni Federov, a member of the Soviet IGY Committee, and colleagues, spiked rumors that nuclear energy had been used to launch Sputnik III, explaining that chemical fuels had been employed, and that the launching technique was similar to that used with the first two Sputniks. They flatly denied that there was a man aboard the new satellite or that an attempt would be made to recover the vehicle, adding that "considerable work" remained to be done before either recoverable satellites or manned vehicles could be built.

Speculation has been rife over why it took the Russians since last November to put another satellite up. One popular view is that the Russians had only two vehicles ready for firing last Fall, and that it took them this long to prepare another one. This view is based on the fact that Soviet military vehicles are being used for satellite launchings, and that productive capability has not yet reached the point where vehicles of this type can be readied on a month-to-month basis.

Another, and less popular, theory is that there might have been some unsuccessful launchings in the intervening months, although this is regarded as unlikely in view of our intensive radar coverage of possible Soviet launching sites from Turkey and elsewhere.

Whatever the real reason, this latest achievement provides ample evidence that the Russians have the capability of launching very large satellite vehicles—a capability which, at this time and in the immediate future, at least, we cannot hope to match.

—Stanley Beitler

Giant C-133 turbo-prop transport is tested at −65°F in mammoth ice box at Air Proving Ground Center, Eglin Air Force Base. *U. S. Air Force Photo*

USAF AIR PROVING GROUND CENTER SIMULATES POLAR COLD IN FLORIDA

The Climatic Laboratory (above), at the Air Proving Ground Center of the Air Research and Development Command, U. S. Air Force, can control the weather on a large scale.

It's used to test all new aircraft and support equipment under conditions simulating arctic, jungle, or desert operations. This unique test facility, the only one of its kind known in the world, can simultaneously test many aircraft under controlled weather conditions, with temperatures from −65° F to +165° F.

It's just one of the advanced facilities at the Air Proving Ground Center (APGC), located at Eglin Air Force Base in northwest Florida, the largest U. S. Air Force base in the world. One of the ten centers of the Air Research and Development Command, the Eglin reservation comprises about 800 square miles, employs 12,000 people and has 32 land and water ranges for bombing, rocketry, gunnery and missile testing—all highly instrumented with modern electronic and optical tracking devices.

APGC conducts engineering and operational evaluations of new weapon systems for the U. S. Air Force; develops new bombing and firing tables; develops tactics and techniques for employing new weapon systems; develops munitions and associated equipment (other than nuclear types); develops aerial targets and scorers.

A new APGC missile launching site, under construction at the Eglin Reservation, will be used for testing of the BOMARC missile and for training missile crews.

APGC also operates the only Drone Group in the Air Force and furnishes pilotless drone aircraft for missile testing for the Army, Navy, and Air Force, and for gathering data for the Atomic Energy Commission.

Three times a year, APGC conducts aerial firepower demonstrations to show civilian and military leaders and foreign visitors, the combat capability of the U. S. Air Force. The APGC facilities and competent personnel are one of the best assurances that Air Force firepower will be more than adequate if ever actually required.

This is one of a series of ads on the technical activities of the Department of Defense.

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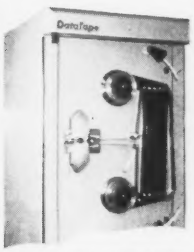
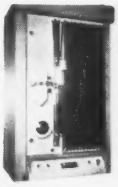


ADJUSTABLE TAPE LOOP ATTACHMENT FOR 5-752 RECORDER/REPRODUCER



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The all-new 5-702 DataTape Recorder is enclosed in a rugged, lightweight case of cast magnesium alloy that is precision machined to assure accurate alignment of internal components. Infinitely superior to sheet-metal cases that bend and yield to stress.

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The highly flexible 5-702 provides 7- or 14-track operation with *exclusive front-panel switch selection of all six tape speeds* from 1⅞ to 60 ips, using 10½" standard NARTB reels or special CEC high-performance reels of ½" or 1" tape.

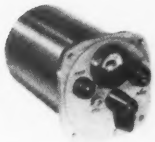
A single cast aluminum alloy case houses seven miniaturized record amplifiers. The system converts readily to 14-track operation by simply adding a second 7-amplifier case and changing tape width.

DOWNSTREAM MONITORING

Use of all-metal-surface playback heads permits simultaneous downstream monitoring of all tape tracks—continuously and virtually coincident with the recording of test data. These reproduce headstacks also allow the 5-702 to be used as a laboratory playback machine.

The new airborne system provides FM, PDM or Analog recording through its interchangeable plug-in amplifiers, and is completely compatible with CEC's 5-752 Recorder/Reproducer.

For complete details, contact your nearest CEC sales and service office or write for Bulletin CEC 1607-X4.



TYPE 11-114 AIRBORNE REMOTE CONTROL INSTRUMENT-PANEL UNIT

Allows remote operation of the 5-702; indicates per cent of tape remaining on supply reel. Requires standard 3⅛" aircraft-panel opening for mounting.

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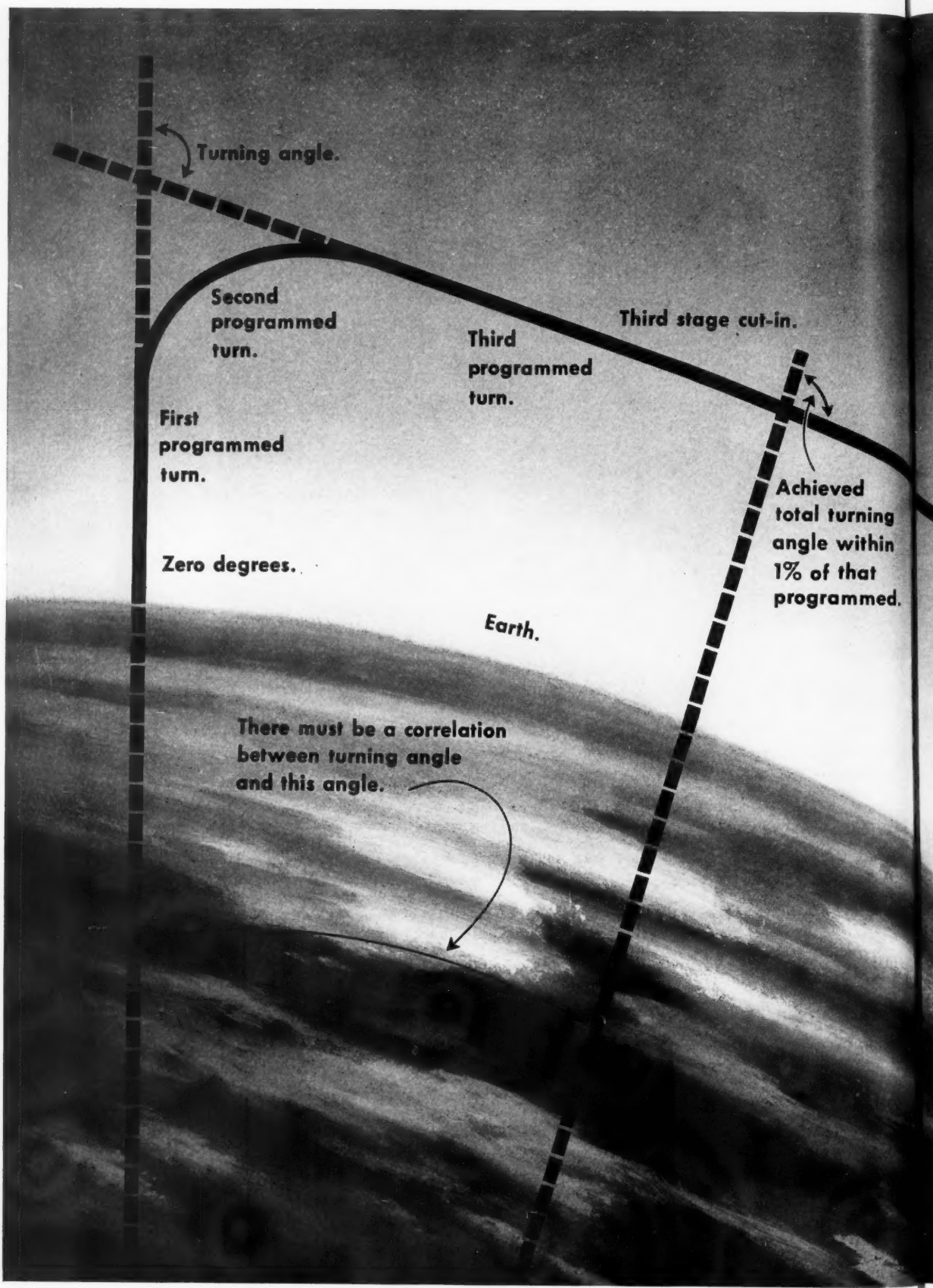

Turning angle.
Second programmed turn.
Third programmed turn.
Third stage cut-in.
First programmed turn.
Zero degrees.
Achieved total turning angle within 1% of that programmed.
Earth.
There must be a correlation between turning angle and this angle.

HOW HONEYWELL HELPED VANGUARD I ACHIEVE A NEAR-PERFECT ORBIT

PUTTING a satellite into a long-lived orbit is somewhat like threading a needle's eye—with the needle up in the sky. Vanguard not only had to hit this hypothetical needle's eye but go through it at the correct angle.

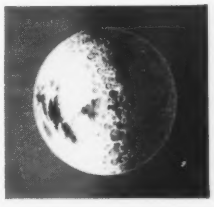
Utilizing no signals or impulses from the ground, Vanguard accomplished this superb feat. Did it with its own powerful rocket engines controlled for most effective utilization by its own complex assemblage of components and systems. The Martin Company, prime contractor, designed and built the Vanguard rocket for, and under the close supervision of, the Naval Research Laboratory.

Vanguard's vital space reference system was Honeywell's contribution. And it was this precise system that, in conjunction with the autopilot, (1) guided Vanguard in the proper flight path, and (2) pitched Vanguard at various angles necessary to achieve near-perfect orbit—so nearly perfect that experts estimate the satellite will remain in orbit up to 200 years.

The turn was accomplished as the diagram at left shows. The total turning angle was achieved within 1% of the angle planned.

The Inertial-type Guidance System, used in Vanguard, is an adaptation of Honeywell's True Inertial System which enables a missile to know where it is—and where it is going—by remembering where it started from. Such systems provide non-jammable guidance beyond the reach of radio or radar.

Inertial Guidance is another example of Honeywell's continuing contribution to space research. If you have problems in the design of systems or components for missiles and aircraft, call or write Honeywell, Military Products Group, 2753 Fourth Avenue South, Minneapolis 8, Minn.



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Optics
Particle mechanics
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Physical Chemistry
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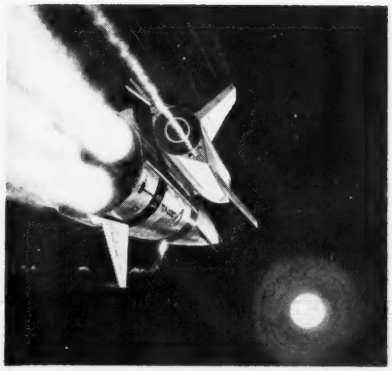

COVER: *This month contributor Mel Hunter provides a fascinating depiction of the X-15 riding piggyback on a Navaho booster in a flight which may bring man closer to the moon than ever before* (*see page 35*).

Astronautics

JULY 1958

From the Editor's Desk

This month's issue of ASTRONAUTICS covers a lot of territory, ranging all the way from a consideration of the makeup and thinking of the two agencies which will bear the responsibility for this nation's civilian and military astronautical programs (page 20) to two stories on what is being done to provide a space age education for the nation's youth (pages 38 and 39).

Of special significance this month is the 10-page section on research and testing beginning on page 24. Louis G. Dunn's article on the supporting research program for the AF ballistic missile effort leads off the section, which also includes several articles based on papers presented during technical sessions dealing with this subject at last month's ARS Semi-Annual Meeting in Los Angeles.

"The First Space Ship" (page 35) introduces an author new to ASTRONAUTICS but well known in the science writing field, Martin Caidin. His first contribution is a detailed study of the X-15 and the problems it will face when it first takes to the air, and beyond, in the very near future.

You'll also find articles dealing with a possible solution to the boiloff problem in missile fueling (page 34) and a first report on data garnered by the two Explorer satellites (page 40).

All this, plus the usual Departments, including a special guest Missile Market columnist, makes the July issue even more interesting, and varied, than usual.

Irwin Hersey

National astronautical program begins

Working groups of NACA's Special Committee on Space Technology are already busy mapping an overall research program for space flight

H. Guyford Stever
Chairman, NACA Special Committee on Space Technology

By the time these words appear in print, there is every likelihood that Congress will have passed a bill bringing into being a national space agency. Creation of such an agency, embodying many of the proposals embodied in the ARS National Space Flight Program, drawn up by its Space Flight Committee (see January, 1958, ASTRONAUTICS, *page 18), means that this nation will, for the first time, be embarked on an all-out effort to conquer space.*

On these pages, you will meet some of the people who will play major roles in the two agencies which will be most deeply concerned with our national space flight program, and also gain an insight into their current thinking about the problems which lie ahead.

THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS will in all probability form the nucleus for the new civilian space agency charged with the responsibility for research in astronautical technology.

Organized in 1915, NACA, in the words of the staff report to the House Space Committee, has for the past 43 years "acted . . . as a

ARPA's Chief Scientist sees IRBM boosters becoming available for space missions in near future and scientific use of ICBM's by early 1960's

Herbert F. York
Chief Scientist, ARPA

THE DEFENSE DEPARTMENT'S Advanced Research Projects Agency was organized early this year to provide coordination and leadership not only for anti-missile missile development, but also for space projects already underway or envisioned by DOD. As such, it represents, again in the words of the staff report to the House Space Committee, "our only attempt at giving immediate direction to the space effort at a fairly high level."

The limit for ARPA's initiation of nonmilitary space projects was set by Congress at one year, ending next February, largely because, even at the time of its formation, plans for a civilian space agency were already developing. Whether ARPA will remain as a permanent DOD component will be decided by the President and the Defense Secretary before the end of the year. Certainly it has filled a basic need in furnishing guidance to the military in planning future space projects at a time when such guidance was imperative.

Under the leadership of Roy Johnson, formerly of GE, as director, Rear Adm. John Clark, former Navy director of guided missiles,

to take shape

By Irwin Hersey, EDITOR OF ASTRONAUTICS

sort of extraordinarily valuable problem-solver for the services and for civil aviation."

The very name of the agency, however, suggests some of the difficulties involved in its conversion into a space agency. The operative words are, of course, "advisory" and "aeronautics."

As the staff report notes, NACA as now constituted is a research agency, with all the traditions of a research agency. As such, all the problems it has solved have been technical, and its operating traditions have been "consultative, advisory, mediatory." The report notes that NACA has no tradition of developing hardware, and that this "lack of any tradition of direction and coordination could be very serious."

"Without drastic, sweeping changes," the report goes on, "it is no mean feat to inculcate a spirit of decision-making in an organization that has lived and thrived on a tradition of peaceful advice-giving. And any space agency, by the urgent nature of its mission . . . will have to know how to rap knuckles."

NACA officials are frank to admit that, as an aeronautical agency, only a small proportion of its research effort—perhaps as little as 10 per cent—has been devoted to space flight. However, they also point out that much of the research that has been done in the field of controls and accessories for air-breathers would also find applications in space vehicles.

Research Dates Back to 1952

Actual NACA astronautical research dates back to January, 1952, when one of its committees began the study of the mechanics of space flight. Since then, NACA scientists have, in the words of the staff report, "swung into problems of space travel as efficient as they previously handled the corollary problems of missile design." The blunt nose concept for missile warheads and the X-15 are products of NACA research efforts. By next year, it is estimated that 25 per cent of the agency's research effort would have been devoted to the space mission even if it

as deputy director, and Herbert F. York, former director of the University of California's Livermore Radiation Laboratory, as chief scientist, ARPA is today a functioning entity, considering a host of proposed space flight projects. Dr. York, in testimony, before the House Space Committee, revealed that more than 200 moon probe proposals alone had already reached his desk.

Operating on Limited Budget

As presently constituted, ARPA is a small agency, operating on a very limited budget. It has not as yet reached its full complement of 25 staff members but should do so in the very near future. Meanwhile, it is attempting to evaluate and decide on the many, and often competing, projects which have been placed before it.

Already underway are two military projects being carried out under ARPA cognizance—the five Air Force and Army moon shots scheduled to get underway late this year, and the AF Pied Piper reconnaissance satellite project. Then, of course, there is the anti-missile development work, which is proceeding apace.

ARPA has operated thus far under emergency funds supplied by DOD, but is seeking $520 million in appropriations, about half of which will be spent during fiscal 1959. About $309 million of the total appropriation will go for development of an anti-missile system and Pied Piper, with some $210 million allocated for space projects. Of this amount, $138 million will be spent on man-in-space research, development of a million-pound thrust engine, advanced satellites, and satellite tracking systems. The remaining $72 million will be devoted to the proposed moon shots.

An indication of ARPA's thinking with regard to use of military vehicles in space research was provided by Dr. York in a recent address before the American Physical Society meeting in Washington, D.C. He anticipated employment of IRBM boosters later this year or early next year, with ICBM's being

was not reorganized to take over direction of the entire civilian space effort.

In its operation, NACA has made effective use of the committee and subcommittee setup, and this same type of organization is likely to continue in use when it becomes the national space agency. The function of these committees is advisory, with decisions the responsibility of the director or, in the case of the space agency, the administrator.

Earlier this year, NACA established a Special Committee on Space Technology under the chairmanship of H. Guyford Stever, associate dean of engineering at MIT, to map an overall space research program.

Under the committee's leadership, seven working groups have for the past few months been dealing with specific aspects of a national astronautical research program. The makeup of the committee, as well as the full membership of the working groups, will be found on this and the facing page.

The work now being done by these groups may go a long way toward shaping the overall research program in astronautics undertaken by the new space agency once it is established.

While no budget has been set up for the new agency as yet, in testimony before the House and Senate Space Committees, NACA Director Hugh Dryden disclosed tentative plans for spending $100 million in fiscal 1959, with this figure being built up, to a level of $300 million annually in three years.

NACA Space Technology Committee

H. Guyford Stever, MIT, Chairman
Carl B. Palmer, Secretary
H. Julian Allen, NACA Ames Lab.
Hendrik W. Bode, Bell Labs.
Milton U. Clauser, Ramo-Wooldridge
Dale R. Corson, Cornell Univ.
James R. Dempsey, Convair
Robert R. Gilruth, NACA Langley Lab.
S. K. Hoffman, Rocketdyne
William H. Pickering, JPL
Louis N. Ridenour Jr., Lockheed
Abe Silverstein, NACA Lewis Lab.
J. A. Van Allen, State Univ. of Iowa
Wernher von Braun, ABMA

Space Technology Committee Working Groups

Space Research Objectives

J. A. Van Allen, Chairman
Dale R. Corson, Vice-Chairman
E. O. Pearson, Secretary
Col. Norman C. Appold, ARDC
Robert Cornog, Ramo-Wooldridge

used for scientific purposes in the early 1960's, and perhaps as early as 1960 itself.

"Following the use of the Vanguard and Jupiter-C rocket system," he noted, "the next big advance in payload launching capability will come about through the application of components and techniques that have been developed in connection with the IRBM (Jupiter and Thor) programs. These components, appropriately modified, will comprise the first stage in space vehicle launchers. Modifications will be primarily in fuel and oxidizer tankage and guidance.

"These IRBM type first stages, or boosters, are in the 100,000-lb class and use liquid-propellent engines burning a special type of kerosene with liquid oxygen. We may expect that they will become available for scientific use in late 1958 or, perhaps, early in 1959.

"Ultimately, they should be capable of launching up to, say, 700 lb of net payload into the easiest orbits. By an easy orbit, I mean a low altitude orbit (say a 200 mile high circular orbit) when launched to the East from a low latitude, such as in Florida, to take advantage of the rotation of the earth.

"For orbits with higher apogees and perigees, or for orbits where the launching is in a more polar direction or from a higher latitude, payload capacity will be correspondingly smaller. The ultimate attainment of the 700-lb payload weight requires not only an IRBM-size booster, but also the use of upper stages designed specifically for this purpose. I do not mean that super or exotic fuels are necessary.

Returnable Satellites Seen in 1959

"At first—that is, say, during 1959—the payloads will not be this large, since optimum systems will not be be available until later. During this earlier period, payloads of 100 to 300 lb can be expected. In 1959, or perhaps 1960, returnable satellites should also become possible, in which case the net returned payload could be approximately one-half of the satellite payload. Further, the escape payload, i.e., to the vicinity of moon or beyond, should be between one-fifth and one-third of the satellite payload.

"The larger fraction applies to a system where the upper stages are specifically designed for use in an escape mission, and the smaller fraction applies in the case where an extra stage is added to a rocket designed for earth satellite vehicle launching. Any terminal apparatus, such as retro-firing rockets for slowing down for lunar orbit capture

Robert P. Haviland, GE
J. R. Pierce, Bell Labs.
Lyman Spitzer Jr., Princeton Univ.

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S. K. Hoffman, Vice-Chairman
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Chandler C. Ross, Aerojet
Homer J. Stewart, JPL
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or landing, must come out of this payload.

"Rockets sufficient to allow orbital capture would cut the payload to about one-half, and rockets sufficient for a soft landing, in which instruments could be expected to survive the impact, would reduce the payload to about 15 to 30 per cent of the escape payload.

"The next step after the IRBM application will involve the use of components of the ICBM boosters (Titan and Atlas) for launching scientific space vehicles.

"The ICBM-size boosters are in the 200,000-lb category and again use liquid engines burning a special type of kerosene with liquid oxygen. We can expect them to become available for scientific use in the early '60's, perhaps in 1960 itself. Ultimately, they should be capable of launching several tons of net payload into the easiest orbits, with correspondingly lesser payloads for the higher energy orbits. Initially, during the 1960 period, we expect to achieve useful payloads of about one ton for satellite orbits. The translunar or escape payloads will correspondingly be reduced in the previously mentioned ratios of one-fifth and one-third. The same considerations with regard to reduction of useful payload in achieving lunar orbits and soft landings would, of course, also apply to these larger vehicles."

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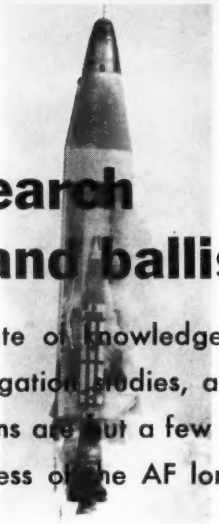


Supporting research and ballistic missiles

Investigations of the present state of knowledge concerning fundamental physical constants, radio propagation studies, and analytical and experimental work on re-entry problems are but a few of the many projects now supplying data vital to the success of the AF long-range missile program

By Louis G. Dunn

SPACE TECHNOLOGY LABORATORIES, A DIVISION OF THE RAMO-WOOLDRIDGE CORP., LOS ANGELES, CALIF.

Louis G. Dunn has had 22 years of experience in aerodynamics, structures, jet propulsion, and guided missiles research. Currently executive vice-president and general manager of the R-W Space Technology Laboratories, he is the author of a large number of technical papers in these areas and co-author of "Airplane Design and Structures." Dr. Dunn received his B.S. and M.S. in mechanical engineering and his Ph.D. in aeronautics and mathematics from the California Institute of Technology, where he remained as an instructor, and later, assistant and associate professor. More recently, he was director of the Jet Propulsion Laboratory and vice-president and director of the R-W Guided Missile Research Div. since its inception. A fellow member of ARS, Dr. Dunn is the holder of a Patriotic Civilian Service Award for R&D work carried on by JPL for the Army.

IN DISCUSSING the nature and scope of the supporting research program that forms a substantial part of the Air Force's IRBM and ICBM projects, it is necessary first to summarize the philosophy of approach to these projects. A supporting research program is of one kind if the goal is the attainment of highly speculative objectives requiring new scientific and engineering knowledge. It is another and quite different program if the objectives are limited to a reduction to practice of basically well-established engineering and scientific knowledge.

The Air Force ballistic missile program represents a major step in the guided missile art. More than that, however, it represents a simultaneous advance on virtually every engineering front, and no major engineering step of this kind can be taken on an urgent time schedule without a substantial supporting research program.

Let us suppose plans for the program require doing only that which has been proved fundamentally sound as to basic knowledge, and requires only straightforward reduction to practice into a new integrated system to meet a new military requirement. Even under these circumstances, if certainty of success is imperative, it would only be realistic to assume that the very reduction to practice will disclose some areas where existing knowledge is sufficiently weak or narrow in scope as to seriously limit confidence in ultimate success.

Balanced Program Demands Supporting Research

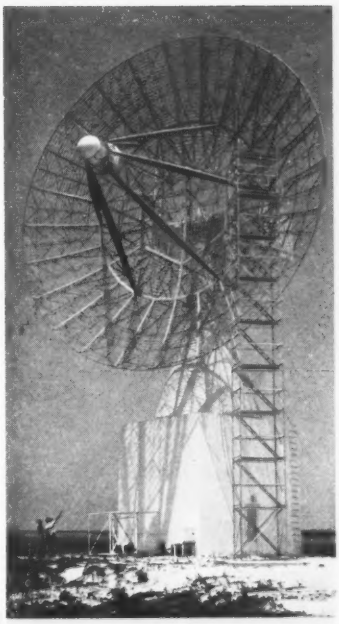
Also, insufficient information in certain areas always tends to complicate design problems, because either large safety factors must be incorporated in the design to make up for the lack of knowledge, or alternative approaches must be considered in parallel as backup programs in case the primary approach runs into trouble. Accordingly, a safe and balanced program destined to the earliest success demands supporting research to widen the boundaries of knowledge between the known and unknown, the tried and untried, and the speculative and nonspeculative, so as to provide a margin beyond that which is needed to fit the military requirement.

It is this kind of approach that has controlled the planning of the AF ballistic missile program. In the ICBM supporting research program, which contrasts with the program for development of major hardware subsystems, it is not necessary to limit the placing of tasks with organizations equipped to provide production follow-on. Instead, research problems have been assigned to organizations whose resources and facilities will provide information most rapidly and economically.

Shortly after responsibility for systems engineering and technical direction was assigned to Ramo-Wooldridge Corp., an analysis was made of the proposed systems to identify areas where information was lacking or contradictory and to assist the Air Force in establishing suitable supporting research programs.

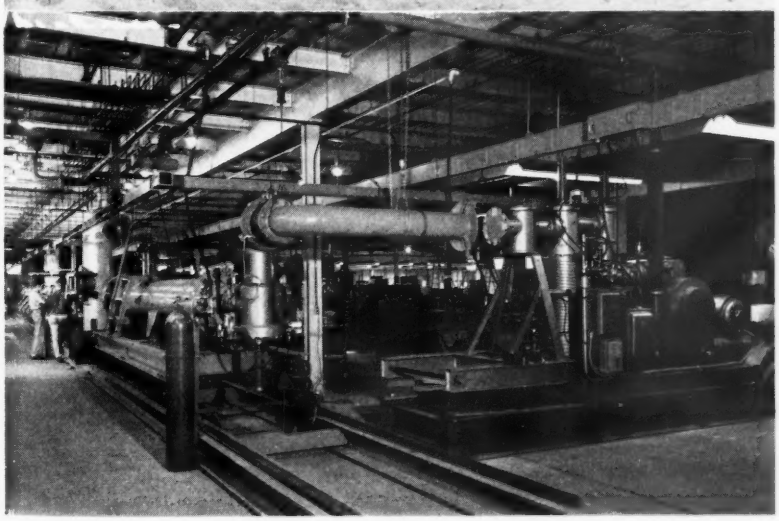
The discussion here is in no way a description of the complete research program. It is rather intended only to illustrate by a few examples the nature of some of the research that was found necessary.

Research work undertaken in connection with the AF ballistic missile effort falls naturally into several separate and more or less distinct categories. For instance, guidance (CONTINUED ON PAGE 80)



Radio propagation studies have helped determine whether telemetry sites such as this one at Antigua could receive data from our largest missiles.

This special Aerojet test sled was used to subject Titan guidance subsystem components to supersonic environmental tests.



Shock tube at Avco's Advanced Development Div. Research Laboratories at Everett, Mass., played a major role in supplying information on laminar and turbulent boundary layer heating under re-entry conditions.

Setting up an off-site missile test center

To flight-test large missiles, a company may virtually be forced to set up a new division at the test site to handle attendant manpower, supply, scheduling, facility, communications and training problems

By W. W. Withee

CONVAIR-ASTRONAUTICS, A DIVISION OF GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.

Wallace W. Withee is assistant chief engineer for test at Convair-Astronautics, where he has been connected with the Atlas program since early 1954. An aeronautical engineer, he was engaged in work on structural design, hydraulic controls, and associated equipment for several aircraft manufacturers between 1936 and 1947, when he joined Convair. At Convair he has held various supervisory engineering posts, such as chief flight test engineer on the XP92A; senior design engineer for propulsion, hydraulic and pneumatic controls, and landing-gear groups working on the R3Y, Pogo Stick, Sea Dart, F-102, Convair 340, and the MX1593 (Atlas); and chief of experimental flight test operations and then assistant chief of flight test on the F-102, F-102A, TF-102A, and Convair 440 aircraft.

THE PROBLEMS of setting up a missile flight test center off a company's home site are many and varied. Certain influencing factors must be known or assumed to initiate planning. For example, the test base from which the program will be operated must be chosen. The nature of the missile and its range requirements will narrow this selection for IRBM and ICBM programs, while smaller missiles of shorter range will allow wider selection of site location. The calendar length of the program is another important factor. A program consisting of one or two firings would be handled differently than a program covering several years.

At the same time that the size of the overall program and the base at which the program is to operate are being considered, the intermeshing of the basic missile design program, the component test program, and the system test and static firing programs must also be considered. All these programs must be scheduled so that test results can be used to greatest advantage.

It is possible to plan a program in which the research and development phase precedes the operational need date by sufficient time to allow a natural progression of design, fabrication, and test. Such a program would allow components to be qualified to the greatest extent possible before being tested in the system in which they are to be used; systems to be qualified before being integrated into the missile configuration; and entire missile with its systems to be fully qualified in so far as possible before the first flight test in the program. It is more likely, however, that the program will be condensed to the utmost to make the operational date as early as possible.

Assuming IRBM or ICBM missiles and a program condensed to the point that design must proceed ahead of test programs to allow for fabrication and delivery time, the requirements for a test center become more definite. The program will require more than a small group of engineers and technicians at the test base, and the base will need more than a blockhouse and firing stand. It will need hangar space for missile inspection and installation of shortage items and revisions based on new information.

If parts must be added to the missile at the test base, and systems and structure revised to the latest design, these parts and the systems embodying them must be checked out both separately and in con-

The flight test itself, night operations, which involve second shifts and overtime, inspection and storage facilities, and data reduction are some of the problems that must be considered in planning an off-site missile test base.

junction with the other systems they may affect. Shop support will grow from a group of technicians primarily concerned with systems on the missile to a more complex group of mechanics and technicians requiring shop and laboratory space in which to do their job.

Consider that the missile has been completed "to the extent possible" before being shipped from the home factory to the test site. "To the extent possible" may be based on many factors. For example, the missile may be in transit seven days between home plant and test base. Then a receiving inspection must be made at the base by both military and company inspectors when it arrives.

All paper work on the missile must be processed, and proper accountability established. Inspection and paper work could take an additional five working days. If a component was not received from an associate contractor or vendor, and the missile was otherwise ready to ship, it would save program time to ship, receive, and inspect the missile without the component, provided the contractor or vendor affected had firm delivery dates for the component approximately 12 days in the future.

It should be assumed, then, that work may have to be done at the test site to install and checkout component shortages. In a condensed program, it is probable that, between the time a missile is in final stages of completion in the factory and the time it is erected on the stand for firing, systems tests and static tests will have given new information to the design groups, necessitating system revision, a component change, or a revision of missile instrumentation at the flight test site.

At this point, it should be made clear that these problems arise primarily in an expedited R&D program, and not in a program with design frozen and few changes expected on the missile at the base.

Second Shift, Overtime Affect Planning

The problem of a second shift and overtime also affect planning for the test site. It is possible to run a single shift, with overtime being used primarily for tests that can be completed in a period beyond the normal work day that will not endanger the operation by causing crew fatigue.

In an expedited program, however, if overtime is to be held to this condition, an extremely close watch must be kept on engineering design and shop fabrication schedules, as well as schedules of associated contractors and outside purchased parts. When this closely integrated schedule shows that key dates are being missed, action must be taken at once, to keep schedule delays from piling up at the test base.

The test firing schedule may have been predicated—even in an R&D program in which testing involves primarily "firsts" and unknowns—on minimum delay caused by the need to solve problems after a missile reaches the test base. When problems of shortages and changes do occur, there are several (CONTINUED ON PAGE 73)

Testing zone with two three-stand test beds. Each zone contains a separate maintenance shop and independent propellant supply and pressurization systems.

Testing giant rocket engines

Facilities such as those described here, capable of static testing our largest powerplants, are a necessary prelude to the step into space

By D. M. Tenenbaum and W. Sprattling Jr.

AEROJET-GENERAL CORP., SACRAMENTO, CALIF.

Tenenbaum Sprattling

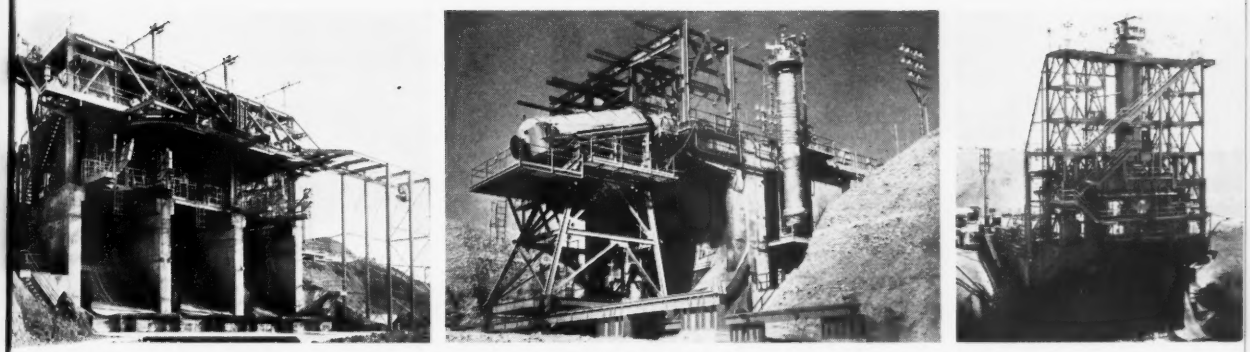
D. M. Tenenbaum, manager of Aerojet's Liquid Rocket Plant test division, is responsible for all testing and instrumentation, including supporting activities for photography and digital computing. A mechanical engineer, he worked for three years in design and development of special aircraft controls and gas turbines before he joined Aerojet in 1948 as project test engineer on the droppable X-60-ALD-4000 ATO rocket for the B-45 aircraft. He followed through with similar work on the B-29 and B-47 aircraft and rocket booster engines for the F-84 and F-86 aircraft, and later was head of the test department for the Bomarc rocket engine.

W. Sprattling Jr., head of the High-Thrust Testing Dept. of Aerojet's Liquid Rocket Plant, is responsible for all engineering testing activities on the high-thrust test stands at Sacramento. Also a mechanical engineer, he was with Bell Aircraft and Boeing's Pilotless Aircraft Div. before joining Aerojet. He is a board member of the ARS Sacramento Section, and was a member of the ARS National Space Flight Committee in 1954.

IN THE SPAN of a decade, rocket engines have grown in this country from practically the back yard variety to the intricate giant that power such missiles at Titan, and we may expect engines in the 1,000,000-lb thrust class in the near future. Trying to keep a jump ahead of the rocket engine has been the static-firing facility where it can be tested for proper functioning and reliability.

One of the country's major facilities for testing high-thrust liquid-propellant rocket engines is the complex of 24 test stands and supporting equipment at Aerojet-General's Liquid Rocket Plant in Sacramento, Calif. Tests of the Titan engine, the Bomarc booster and the Vanguard second-stage are conducted at this facility, which can handle engines with thrusts up to 1 million lb.

The test area contains four testing zones, each with two 3-stand test beds. These beds, which have a concrete thrust-absorbing structure formed as a cantilever "C" clamp, are spaced 200–400 ft apart, depending on their thrust rating. A single control building, heavily protected by reinforced concrete and ballast, directs all six stands in a two-bed zone. Each zone also contains a steel Butler-building shop with about 10,000 sq ft of floor space for maintaining test-stand equipment and checking out devices to be tested, and an independent pressure source and supply system, fuel supply and/or distribution system, flame deflectors, water supply and distribution system, and vacuum-insulated tanks for storing and distributing liquid oxygen or similar equipment for handling other oxidizers. Rocket engines tested in the facility require equipment for handling nitric acid, kerosene, liquid oxy-



Versatility of the big stands is shown in these photos. At left, motorized working platforms and test-engine mounting rigs speed test operations. Firings can be made horizontally (center) or vertically (right).

gen, and unsymmetrical dimethyl-hydrazine, among others.

These main stands are augmented by a separate complex of five buildings, each with two test bays and two sets of controls and instrumentation for "cold-flow" testing of pumps, turbines, valves and gas generators, and for calibrating flow meters. Both test bays in a building can be operated at once. In addition to the five buildings, there is a facility for calibrating rotating-vane or pressure-drop flow meters, against a volumetric standard with cryogenics, fuels and water.

Obviously complex testing of this type requires something special in the way of instrumentation. The strain-gauge system for measuring pressure, force and acceleration employs transducers with identical electrical characteristics and tightly controlled relations between electrical calibration steps and the parameter to be measured. The system takes minimum time for setting up a test and allows direct reading of test records.

Turbine-type meters, which generate an a-c output directly proportional to volumetric rate, form the basis for the main flow-measuring system. The a-c signal from these meters is recorded directly and converted to d-c analog for display on direct-writing recorders. A thermocouple system with a 32-F reference measures temperatures over the range −300 to 2500 F.

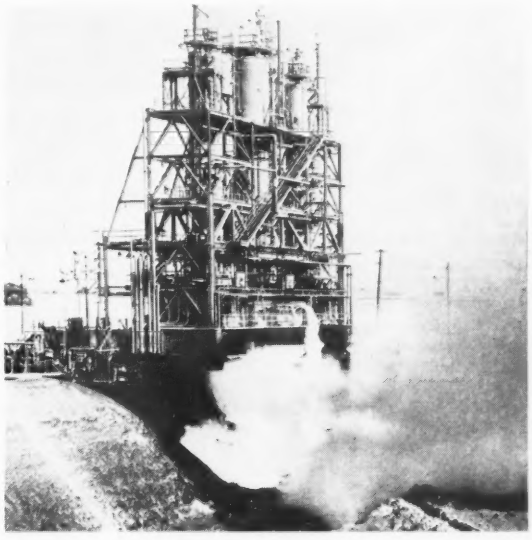
Varied Instrumentation Required

Platinum resistance-thermometer bulbs are also used to make very accurate measurements of materials at very low temperatures. And there is equipment for measuring rotational speeds, linear or angular position, electrical-control inputs and time intervals.

Available for recording measurements are strip-chart makers, visual indicators, multichannel oscillographs, and a "Millisadic," which sequentially samples and digitalizes analog information at the rate of 400 samples per second for tape recording and subsequent processing onto punched cards for the IBM 704 computer.

Certain performance goals led to the form the facility actually took. First, it was to give the greatest testing capacity possible per dollar invested. This led to common controls and instrumentation—one set to each three stands—to common propellant storage, water supply and pumping systems, and to maintenance shops for each pair of three-unit stands.

Second, the facility was to allow a high rate of testing with minimum support from other areas. Toward this end, test stands were given motorized working platforms and test-engine mounting rigs. Means were provided to permit virtually all test-stand selection and servicing by means of switches in the control room, with in- (CONTINUED ON PAGE 44)



Titan engine in a static firing test.

Radioactive tracers— New aid to rocket instrumentation

Their use is helping engineers to get accurate measurements of structural material erosion, combustion flow, propellant burning, and miss distances

By David E. Shonerd

ERA ENGINEERING, INC., SANTA MONICA, CALIF.

David E. Shonerd is a graduate of the California Institute of Technology, where he took a BS in mechanical engineering, an MS in aeronautical engineering and an AeE in jet propulsion. He received a Guggenheim National Jet Propulsion Fellowship to Cal Tech in 1950, following experience in rocket design and testing at the Jet Propulsion Laboratory and at the U.S. Naval Ordnance Test Station, China Lake, Calif. From 1951 to 1954, he worked on missile systems analysis for Hughes Aircraft Co., and he was project engineer for the Air Force hypersonic test vehicle at Aerophysics Development Corp. from 1954 to 1957, when he became president of Era Engineering.

RADIOACTIVE TRACERS, which reliably emit particles and waves with well-known properties, are providing a new approach to many rocket instrumentation problems which have long plagued research and development engineers.

Through their use, engineers are obtaining continuous information on erosion of nozzles and solid-propellant grains, and ablation of rocket structures due to aerodynamic heating; tracing the flow of propellants or combustion products through the combustion chamber or nozzle; and determining missile trajectories near a target—that is, measuring miss distances.

Beta and gamma radiation are normally used, the energy spectrum varying considerably with the source material. Particle energy, source strength (which determines the rate of particle emission) and source half-life must all be considered in the application of radioactive elements to rocket and missile instrumentation.

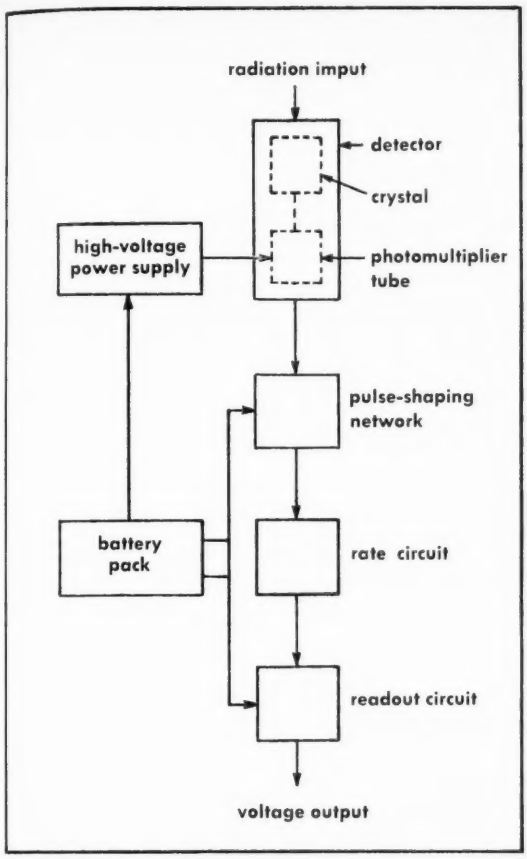
For example, high energy, long life, and high radiation levels are used with miss-distance indicators to permit detection of wide misses. On the other hand, low radiation level, shorter half-life, and relatively low energy particles are suitable for measuring material erosion.

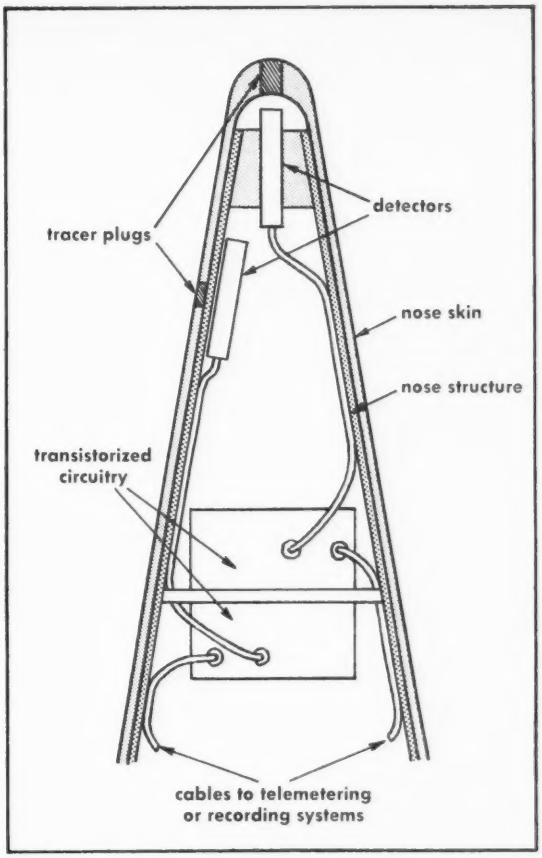
Two types of radiation detectors are widely used in such instrumentation techniques—the geiger tube and scintillation detector. Both put out a series of electrical pulses, the number or rate of these pulses serving as a measure of the radiation level.

Miniaturized Electronic Packages Used

A wide variety of vacuum tube and transistorized circuits has been developed to count pulses originating in the detectors. Rates of several hundred thousand counts per second can be detected with miniaturized electronic packages that function in rocket environments with very high reliability.

Two radioactive tracer devices in operational use with off-the-shelf hardware are a material-erosion-rate instrument (MERI) and a miss-distance indicator (MDI). Both MDI and the MERI consist basically, as shown in the drawing on the opposite page, of a radioactive tracer, a detector to measure radiation level, and elec-





Basic Radioactive Tracer System (left), and (right) the system, as material erosion rate instrumentation, installed in a rocket nose to measure skin ablation in hypervelocity flight.

tronic circuitry to convert radiation level to an appropriate electrical signal.

In MERI, the tracer, impregnated in the material being eroded, indicates a decrease in radiation level proportional to surface material removed. MDI's radioactive tracer is in the missile and the detector in the target. Radiation level thus indicates proximity of the missile to the target.

The radioactive materials in either system are, of course, negligible in size and weight. The tracer contributes less than 1 per cent of the material in MERI, while the gamma-ray emitter for MDI is usually encapsulated in a machine screw.

The MERI system, an example of which is shown on this page, consists of small detector probe, electronic circuitry for measuring radiation level, and the radioactive tracer. The entire instrument is subminiaturized and has been tested for operation in free-flight or static-firing rocket vehicles. The radiation detector rides in a small cylinder connected to the electronic circuitry by a cable, which can be varied in length from a few inches to 6 ft. The electronic components can, therefore, be put in a convenient place in the rocket, with the small detector probe near the activated material. The area to be tested for erosion may be in the tip of a rocket's nose cone, in the leading edge of a jet vane, in the throat of a rocket nozzle, or in other areas usually almost inaccessible.

How Tracer Is Introduced

The tracer for MERI can be introduced uniformly into material in several ways. For instance, a small hole can be filled with tracer, or small amounts of tracer can be added directly to plastics, such as Teflon, during the fabrication of a part. For any given metal, metal oxide, or plastic, a binder with nearly the same physical and thermal properties as the original material can be procured to hold the few micrograms of the emitter used. Moreover, the entire component or structural element can be irradiated to give low emission for MERI detection.

MERI can give an accuracy of better than 5 per cent for materials up to approximately 4 in. thick. It will respond to a full-scale step-function thickness in less than 1.0 sec, (CONTINUED ON PAGE 64)

Nondestructive tests and quality control

Increasing complexity of rocket engine and missile systems makes this least expensive of test methods vital in assuring component reliability

By R. P. Frohmberg

ROCKETDYNE, DIVISION OF NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.

IN VIRTUALLY any discussion of quality control in the rocket engine and missile industry, the subject of reliability must be considered. Reliability may be viewed as the overall quantitative measure of the success of the design and manufacture of a given machine, and it has been a problem since man devised machines. It was the increasing complexity of this problem which led to the development of modern quality control.

Experience has shown that complex mechanical equipment does not possess the infallibility once ascribed to it, and that lack of judgment and analytical ability on the part of a machine during malfunction is frequently fatal to the machine. In addition to this, the missile and rocket engine industries are faced with the problem of condensing enormous development and test programs into a very short span of time. This naturally lays unprecedented stress upon

Richard P. Frohmberg, chief of Rocketdyne's Production Development Laboratory, joined the company in 1955 as a senior research engineer in charge of the metallurgical laboratory and was promoted to his present position in August, 1956. Before joining Rocketdyne, Dr. Frohmberg, winner of the 1956 Henry Marion Howe Award of the American Society for Metals for his work on the causes of delayed failure fatigue in high-strength steels, was for six years an instructor and research associate at Case Institute of Technology. He holds Bachelor's, Master's and Doctorate degrees from Case.

METHODS OF EVALUATING QUALITY OR RELIABILITY

OPERATIONAL SERVICE

BLOCK OR STAND TESTS
(COMPLETE ENGINE)

BENCH TESTS
(ASSEMBLIES)

NON-DESTRUCTIVE TESTING
(DETAIL COMPONENTS)

the quality control necessary to produce acceptable reliability.

The essence of modern quality control is to provide a high degree of product quality and reliability in as economical a manner as possible. If enough money is expended, it may be possible to build a machine which will approach infallibility. However, by judicious use of the tools of quality control, it is possible to assure an acceptably high quality level at a reasonable price.

The first question is that of evaluating reliability. The direct and positive measure, of course, is the operational performance of every engine during flight. Any such approach in the case of rocket engines and missiles is so costly that it is absurd. It is possible to approximate the operational performance with block or stand tests on the completed engine assembly. But even static firing tests on engines before delivery or on engines mounted in the vehicle are so costly that every effort is made to screen systems and subassemblies effectively by bench testing before engine assembly. Prior to buildup of components and assemblies, it is possible to subject the detail elements to visual examination, pressure tests, dimensional checks, radiography, ultrasonics and similar classical nondestructive tests.

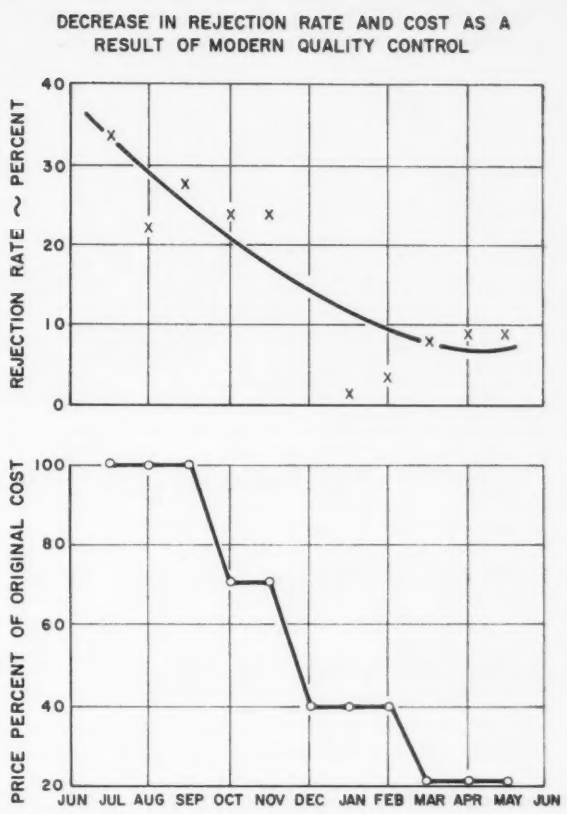
Is Least Expensive Test Method

The four basic test areas or methods of evaluating quality are depicted on the opposite page. The field of nondestructive testing remains as the foundation of this concept. Although the four methods can be viewed in different ways, the most significant difference for the purpose of this discussion is the matter of economics. Nondestructive testing is by far the least expensive of all test methods and, if judiciously applied, can be the most economical.

It has long been realized that rough castings, weldments and forgings must be evaluated from a quality viewpoint before any more money is put into them. This is where nondestructive testing fits into the overall picture. It is a significant link in the long chain from raw materials to finished product, and modern industry has found that it simply cannot afford to bypass nondestructive testing as a basic tool of quality control.

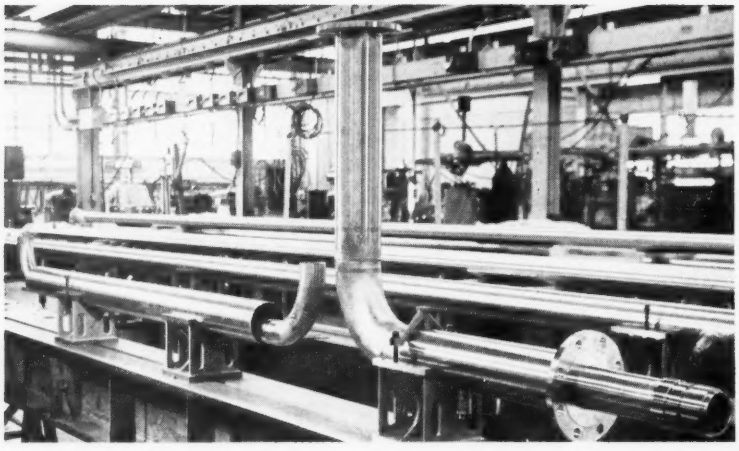
One vital point to consider is the selection and specification of suitable nondestructive tests by the design engineer, who seeks assurance of a quality casting, forging or weldment.

The answer is not always X rays, nor magnetic particle inspections, ultrasonic tests or any other single tool. For example, in the surface hardening of metals, closure welds on pipes and vessels, and heat treatment of steel, it has been found economical to assure quality by process control.



The design engineer must consider the economics of various testing techniques and the information received for money expended. Examples are numerous of the indiscriminate use of radiography, magnetic particle and other nondestructive tests simply because the test is new or appears useful. In short, it is necessary to appreciate the capabilities and limitations of various test methods during design of the product to which they may be applied.

In the ideal case, a quality control engineer with a strong background in nondestructive testing is a vital part of the design team. Just as the metallurgist aids in the selection of material and its processing, and the stress analyst offers his knowledge in a specialized field, the nondestructive testing engineer can aid in an educated choice of quality control measures. Perhaps a small change in configuration, immaterial to the performance of the part, might be necessary to facilitate placement of radiographic film or coupling of an ultrasonic transducer. Something as simple as the manner in which drawings are dimensioned can materially assist the bench inspector when he lays out (CONTINUED ON PAGE 58)



High-vacuum transfer lines in production at Consolidated Electrodynamics Rochester Div. Tees and ells in all sizes permit adaptation of the lines to all kinds of configurations.

New wrinkle in fueling rockets

Vacuum-jacketed transfer lines virtually eliminate boiloff losses

AT OUR missile bases, rockets are generally fueled through a transfer line running from a storage tank or generator located at a suitable distance and convenient to all launching pads. This method is necessitated by the difficulties involved in scheduling truck deliveries to the launching site and the proper timing of unloading without creating traffic jams. The presence of the trucks in itself gives rise to extra hazards.

But this method of fueling also has its disadvantages, the major one being the great loss through boiloff.

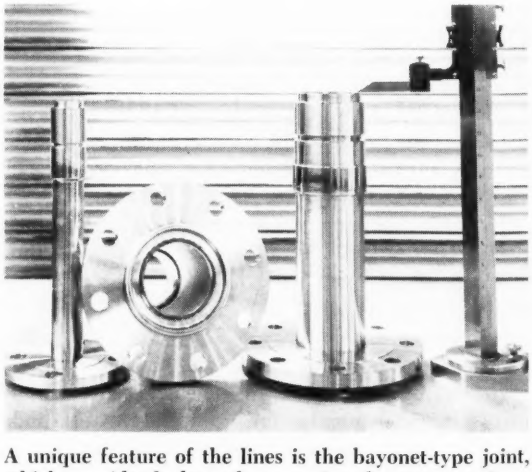
Uninsulated lines, first used as a matter of expediency in getting rocket test facilities into operation, depend for insulation on the snow coating formed by the freezing of atmospheric moisture. There is considerable boiloff, however, during the chilldown period, and in warm areas, where the ice buildup is rapid, flaking off can also be pronounced, exposing considerable areas to added boiloff.

More recently, asbestos, foam glass, cork and glass wool have been used as insulation.

The extremely wide range of heat transfer conditions that may exist on liquid oxygen transfer lines as a result of the use of insulation has been studied by a number of researchers. D. A. Van Gundy and R. B. Jacobs of the National Bureau of Standards Cryogenics Engineering Laboratory at Boulder, Colo., for example, recently reported on the characteristics of four different types of conventional insulation. These were investigated first, to find the best insulating method for lines already set up which could not be interrupted and, second, to provide a comparison for vacuum-jacketed lines.

A reflective, concentric aluminum-shell insulation was the first to be tested on a 30-in. long cylindrical section. Thirteen polished concentric shells were placed $^1/_2$ in. apart in the $6^1/_2$-in. thickness tested. Spacers and bulkhead section ends were of light gauge stainless steel. The researchers found that the unit heat transfer was 186 Btu/ft/hr, or, about half the heat transfer to a frost-insulated pipe.

A rigid cellular glass insulation, with a density of 10 lb per cu ft, was tested next. United heat transfer ranged from 72 (CONTINUED ON PAGE 66)



A unique feature of the lines is the bayonet-type joint, which provides leakproof connections between sections.

The first space ship

The X-15, slated to take to the air early next year, is just that—a rocket vehicle capable of carrying a man across the threshold of space as it travels at hypersonic speeds to an altitude of 200 miles or more

By Martin Caidin, Astronautics Field Correspondent

Illustration by Mel Hunter

WHEN NORTH AMERICAN'S X-15 rockets beyond the atmosphere some time early next year in an optimum performance speed and altitude run, its pilot will be hurled forward by forces roughly equivalent to the combined power at full throttle of 250 World War II B-17 heavy bombers.

Reaction Motor's XLR-99 rocket engine, of 60,000-lb thrust, mated to the unusual NACA design-form of the X-15, adds up to something more than just a rocket-powered research vehicle. The ship is actually the world's first *hypersonic* aircraft.

This stub-winged machine advances so far beyond the current state of aviation that it can no longer be classed merely as an airplane. Its ultimate single-stage performance calls eventually for speeds of Mach 7. With the new fuels now under development, it may reach Mach 9. Its maximum altitude was originally estimated at 105 miles. New estimates point as high as 200 miles.

In every respect, the X-15 will leave the earth's atmosphere completely behind it and forego aerodynamic lift during the upper part of its flight for centrifugal lift. In essence, this is not an airplane. It is a re-entry vehicle—a space ship, if you will.

THE MEN WHO'LL FLY THE X-15

Left to right, Joseph Walker, senior NACA test pilot, who will take the X-15 up on its first space flight; Capt. Iven C. Kincheloe, who will test its full capabilities for the Air Force; and Scott Crossfield, North American test pilot who will be first to fly the ship before it is turned over to the Air Force.

In flight, the earth's atmosphere will lie beneath the ship's wings, and the science-fiction writer's dreams of flight in space will become first-hand reality to the X-15 pilot. He will fly so high that he will be beyond the point of light diffusion, and will rely on artificial illumination, even in direct sunlight, to read his instruments.

Should there be more than a very minor error in control of the descending ballistic trajectory, the X-15 may plunge into an atmosphere that resists its passage with all the solidity of a thick, viscous mass. It is estimated that deceleration forces will reach at least 9 g's. North American test pilot Scott Crossfield has undergone centrifuge deceleration to this figure, and not without painful results.

Some 50 ft long, the X-15 is a thick, cylindrical aircraft with lines which do not even suggest its fantastic capabilities. The ship will weigh about 16 tons in final flight configuration. However, this weight rapidly diminishes in flight as its engine eats up fuel (possibly anhydrous ammonia) and lox. For more than half its length, the X-15 is a flying fuel tank. Integral with the body structure, each tank contains baffle dishes to control fuel sloshing and center of gravity. Within each tank is tubing, 12 in. in diam, which serves as a fuel line and also provides structural bracing.

Immediately behind the cockpit, on either side of the fuselage, is a large bulge of beryllium which extends all the way to the rear of the ship. Designed primarily to reduce drag between the fuselage and the stubby wings, these bulges also house the bulk of the aircraft's wiring, plumbing, and power equipment.

Everywhere in its design the X-15 appears to be breaking new aerodynamic ground. The vertical stabilizer has a control surface hinged so that the whole upper half rotates for control, while the lower half remains fixed as a vertical stabilizer. Most unusual is the 12-in. diam of the trailing edge of the structural member. A ventral fin, 4 ft long, provides additional aerodynamic stability and is jettisoned on landing, when the ship drops down to rest on two skids which telescope out of blisters in the rear fuselage, beneath the horizontal stabilizers. The latter are about 4 ft long, with a 15 deg anhedral. There are no horizontal control surfaces.

Re-entry Poses Big Question Mark

Oddly enough, acceleration—often regarded as a stumbling block by science-fiction writers—is not likely to be a problem in the X-15. It has yet to prove a problem in rocket-powered ships, even including the X-2 in its all-out vertical ascent to 126,000 ft. In that flight, AF Capt. Iven Kincheloe, who piloted the ship, has said he experienced somewhere between 2 and 3 g's in the ascent, hardly enough to bother him.

Rather it's the return to the atmosphere that constitutes the big problem. The X-15 is going to fly right out of the atmosphere and then fly back in again. To a ship traveling at hypersonic speeds, even the smallest amount of air means trouble. Its wings will exert lift, resulting in drag forces, friction, and aerodynamic heating, with temperatures running as high as 1000 F even if the ship returns to the atmosphere in a shallow approach.

Should the X-15 move off this slide rule re-entry

trajectory and slam back into the atmosphere, not only will temperatures mount still higher, but the pilot will have other problems. During the long deceleration period he will be in the clutches of inertia. Despite the drag imposed on the ship, his body will want to keep on moving.

Centrifuge tests have provided some graphic evidence of what the ship's pilot will be up against. Sustained for an indeterminate period, 9-g deceleration is rugged. The head must be securely strapped or neck whiplash and unconsciousness results. Internal organs are slammed forward and the stomach distended. Blood attains a mass and solidity akin to mercury, and rushes to the forward part of the brain and the eyes.

X-15 Attitude Is Critical

In such tests, Scott Crossfield several times lost consciousness from the tremendous pressure of the blood against his brain. With straps and webbing snapping, his face became a grotesque Halloween mask as he was subjected to the deceleration forces the X-15 may encounter.

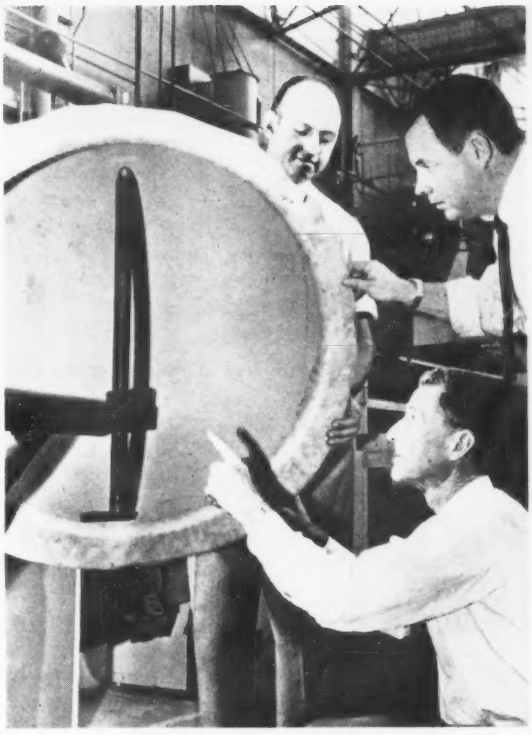
It's obvious, therefore, that the attitude of the X-15 is critical to survival of its pilot and accomplishment of its mission. The main problem is to keep the ship from slamming broadside or tail first into the atmosphere in its descent. Control surfaces, such as a horizontal tail fin, are useless since there is no air upon which they can act. Reaction forces must thus be employed.

For this purpose, the NACA-NAA engineering team has employed hydrogen peroxide jet streams, 1.5 in. in diam, in the nose (to correct pitch and yaw) and in the wingtips (for roll control). These will be used for orientation only *within* the original flight path, since no changes can be made in the ballistic trajectory the ship will be flying.

Attitude control during re-entry is only part of the problem. An equally difficult control task will face the pilot during high speed runs in the upper atmosphere, where stability is of prime importance. In moving from subsonic through supersonic to hypersonic speeds, pressure centers on the fuselage, wings and tail will shift, and shock waves as hard as steel will ram against the ship.

Control movements which overcome flight difficulties between Mach 1 and Mach 2 or 3, for example, may prove worthless in the Mach 4–6 range. How will these problems be solved? Experience alone will provide the answers.

No matter what the attitude or degree of flight from the vertical when the X-15 re-enters the atmosphere, it's going to have tremendous kinetic energy, which means heat problems of a type never before encountered by a manned (CONTINUED ON PAGE 75)



North American engineers inspect X-15 fuel tank for thinning out after drawing and spinning operations on stainless steel pressure vessel.

These high-pressure lines on X-15 are brazed, rather than thread fastened, to provide tighter joint.

J. M. Rowland of Martin-Denver addressing the Littleton, Col., Space Age Workshop at its final session in company cafeteria.

Space age workshop

Here's how Martin-Denver provides local school teachers with the answers to questions their students ask about rockets, missiles, and astronautics

WHAT IS industry doing to assist educators in training our children in this modern and very technological world?

The Martin Co.'s Denver Division believes that industry has a responsibility to the community and to the children residing in it, and consequently is doing something about it.

For many years, the aircraft industry as well as other industries have cooperated with schools and colleges by supplying funds, talent, and supplies so that students and teachers alike could keep up to date with the rapid advances of modern scientific and manufacturing techniques. For probably the first time in the history of industry-school cooperation, however, a "space age workshop" has been conducted for teachers. The results have been most gratifying.

Schools Wanted Professional Help

The Littleton Space Age Workshop came into being as a result of discussions between the information services office of Martin-Denver and the Littleton, Col., Board of Education. The Littleton schools were anxious to receive professional help in the fields of rockets, guided missiles, and astronautics, and Martin was certainly anxious to provide such help.

It was decided that, although the students in all grade levels were interested in rockets and space flight, the best way to get this information to them was through their teachers. Unfortunately, many of our modern children know much more about jets, rockets, etc., than do their teachers. By establishing a teacher's workshop, two things could be accomplished. First, the teachers themselves could be brought up to date on many technological subjects, and second, they would be able to integrate much of this new information into many standard courses.

The workshop was set up as a 10-week course, with $2^1/_2$-hour sessions held every Tuesday evening. Teacher participation was strictly voluntary. It is interesting to note that, although participation was voluntary, over 125 teachers of an entire faculty of 160 signed up for the course. The Littleton school system cooperated by giving teachers credit for workshop participation.

Each session of the workshop was divided into three parts. The first hour was devoted to a presentation by a Martin official dealing with the specific field of activity in which he was engaged. During the second hour, the teachers would break up into four separate clinic groups, made up of primary, intermediate, junior high school and senior high school teachers. Martin personnel would be present at these clinics to lead the discussion and answer questions. In the last half-hour, the entire group was reassembled, further questions asked and answered, and the entire session summarized.

In order that the subject (CONTINUED ON PAGE 69)

Educating youthful rocketeers

Program established by ARS Florida Section directs interest of youngsters away from dangerous experiments and toward constructive projects

By Capt. R. F. Sellars (USN)

DIRECTOR OF NAVY TEST, AF MISSILE TEST CENTER, PATRICK AFB, FLA.
PRESIDENT, ARS FLORIDA SECTION

ANYONE CONCERNED over the future of this country can not help but be encouraged by the interest engendered in rocketry, guided missiles, and space flight among the nation's youth in recent months. It is a healthy interest, and indicates there will be no dearth of rocket engineers or astronauts in the years that lie ahead. As such, it should certainly be encouraged.

However, there can be little doubt that some of the effects of this interest are causing serious concern not only to the parents of these youngsters, but also to all of us in the rocket and guided missile business.

A rocket can be, and often is, a dangerous plaything. There is little need at this time to dredge up the many serious accidents which have befallen youngsters, as well as adults, in the course of unauthorized rocket experiments in recent months. You can scarcely pick up a newspaper these days without finding a story about an accident of this kind.

Too many of us seem to feel that kids are kids and nothing can be done about it. This is far from the case, as the experience of the ARS Florida Section may indicate.

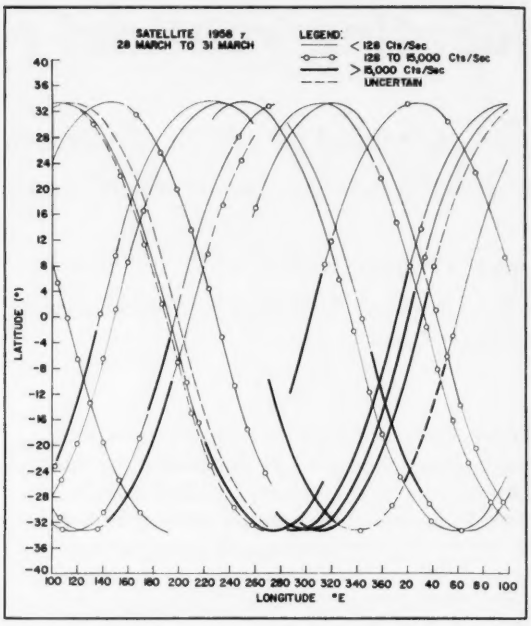
Interest Is Awakened Early

In one respect, those of us here in the Florida Section may be more fortunate than rocket and missile engineers elsewhere from the standpoint of providing aid for youthful rocketeers. Youngsters in this area, where the world's best known missile test center is located, hear talk about rockets and guided missiles almost from the time they're in their cradles. As a result, their interest in the subject is generally awakened at a very early age.

Unfortunately, however, all the talk they hear about missile testing at (CONTINUED ON PAGE 66)

Rocket Research Society of Greater Cocoa, organized by Florida ARS Section.

Society officers. In foreground (left to right) are Joe Carbone, president, and John Bachmann, vice-president. Seated, in same order: Bob Roth of Cocoa High School, sponsor; Bob Reed, secretary; and Ed Beveridge, treasurer.



SUI plot of geographic latitude vs. longitude for Explorer III orbits, showing intensity of radiation. High-intensity radiation appears as a belt at low latitudes.

Report from the Explorers

Partial data show no problems with temperature control or micrometeorite erosion, but warn of possible high radiation

INITIAL REPORTS on data from Explorers I and III, presented recently to a joint meeting of the National Academy of Sciences and the American Physical Society, indicate that, while man will have little to fear in the way of extreme temperatures or micrometeor erosion of the vehicles he travels in when he first ventures into space, he may be in danger from a hitherto undiscovered band of intense radiation at altitudes of 1100 km and above.

The big news at the meeting was provided in the radiation report, written by James Van Allen and his associates at the State University of Iowa. Dr. Van Allen and his co-workers found that cosmic ray counts from the two satellites were as anticipated for altitudes below 1000 km. These counts—30 to 40 a second, times a scaling factor—extrapolated to lower altitudes agree substantially with counts taken by sounding rockets.

At altitudes above approximately 1100 km, however, the Van Allen team believes cosmic ray counts soared to more than 35,000 a second. They found that the Explorer III geiger counter blanked out at altitudes above 1100 km. They have found no evidence that the counter or its power supply should have been disrupted by satellite temperatures, and there was no indication from the telemetry system, which has a temperature-sensitive frequency, that extreme temperatures occurred.

While the satellite might have passed through regions almost free of cosmic radiation, this appears unlikely because a magnetic field on the order of 1 gauss in strength and extending with great uniformity for thousands of kilometers would have to exist to exclude such radiation.

Counting Rate Seen Reduced to Zero

They reason, consequently, that the geiger tube encountered such intense radiation that dead-time effects reduced the counting rate to essentially zero. Testing this idea by subjecting a spare Explorer I to X rays in a laboratory setup, they found that at high fluxes few pulses from the geiger tube had sufficient amplitude to operate the scaling circuit of the geiger telemetry link, the counting rate returning to the range that could be telemetered, and that for very high fluxes no pulses had sufficient amplitude to cause counting.

The X ray rediation necessary to blank the geiger tube was equivalent to 60 mr/hr, or 0.3 r in 5 hr. Nominal permissible radiation dosage for humans is 0.3 r/wk. Thus, a satellite carrying men at altitudes above 600 miles would have to be shielded if this radiation proved to be X rays.

Dr. Van Allen and his (CONTINUED ON PAGE 64)

Venus, in blue light, 200-inch Palomar telescope

SPACE FLIGHT and NUCLEAR PROPULSION

A drastic reduction in vehicle mass ratios... substantially increased specific impulse values... a capability for achieving very high speeds... these are some of the significant advantages that will come from the application of nuclear energy to space flight.

A number of different propulsion systems have been proposed to utilize nuclear reactions. The simplest system consists of a fission reactor through which the propellant is passed, heated, and then expanded through a rocket nozzle. Fission reactors can also be employed as a source of energy to generate electric power, which in turn can be used to accelerate ions or charged particles, or to create and accelerate a plasma. And fusion reactors, when developed, can be used to generate electric power for the same purposes. In addition, in the case of the fusion reactor, there is the attractive possibility that the reaction energy can be used directly without conversion to electric power.

The fission-powered thermal propulsion system will probably constitute one of the next major advances in space technology. As an example of the gain which can be achieved, consider a vehicle with a payload weight of about 25 tons for a manned flight to one of the nearer planets, landing, and returning. Powered by chemical rocket engines, the takeoff weight for such a vehicle would be 50,000 tons. But powered by a fission-thermal propulsion system, weight at launch would not exceed 500 tons... a 100-fold reduction in the mass ratio. Considerably greater gains are predicted for the more advanced systems.

Systems studies and advanced research in the application of nuclear energy to the requirements of space flight are in progress at Space Technology Laboratories. This work illustrates the emphasis at STL on the exploration and development of new concepts and techniques in ballistic missile and space technology.

Both in support of its over-all systems engineering responsibility for the Air Force Ballistic Missile Program, and in anticipation of future system requirements, STL is engaged in a wide variety of analytical and experimental research. Projects are in progress in electronics, aerodynamics, hypersonics, propulsion and structures.

The scope of activity at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding professional opportunities on the STL Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA

Missile market

ROBERT H. KENMORE, *Editor*

To afford readers of this column a better cross-section of professional Wall Street opinion about investments in the missile industry, occasional guest columnists will, in the future, be asked to air their views in this space. This month's guest columnist is Marvin S. Raphael of the Hayden, Stone & Co. Investment Research Dept.

—R.H.K.

BY MARVIN S. RAPHAEL
Hayden, Stone & Co.

THE TRANSITION from manned aircraft to missiles becomes more evident every day. The present defense program, for example, calls for a reduction in the number of AF wings to 105 by the end of fiscal 1959 from 117 this fiscal year and 137 last year.

While manned aircraft will no doubt continue to play an important role for some time to come, the trend is obvious. AF estimates are that about 90 per cent of all air defense missions will eventually be taken over by missiles, with some 50 per cent of SAC's job and 30 per cent of TAC's missions also handled by missiles in time. The Navy also expects that within five years 35–40 per cent of its total expenditures for aircraft would go for missiles, compared with 12 per cent in fiscal 1957.

What does all this mean? It means that, with this transition to missiles, R&D work will become increasingly important. Through such work, newer and better missiles and related products will be developed. While R&D work is expensive, it may result in commercial products that could benefit mankind.

Why should an investor purchase stocks in the missile field? One important reason is that our present budget is the largest in our peacetime history, with some $40 billion of a total budget of about $75 billion going for defense. Unless the world situation takes a turn for the better, it appears likely that defense spending will increase, rather than decrease.

This being the case, greater volume alone for companies in the field should generally bring up net income. Of course, renegotiation is an important consideration, but it is sometimes necessary to assure better work and greater productivity to help an industry along. Many companies not selling directly to the government are not always limited as to their profits. However, since the government is requiring companies to contribute more funds for plant and equipment and for the financing of military work, cash payouts to stockholders will continue to be limited. As in all growth industries, dividends are generally smaller than average, although the long-term capital gains prospects usually more than make up for this.

While anyone studying the missile field knows the giants of the industry, such as Boeing, Douglas, General Dynamics, Lockheed, Martin, North American, etc., there are many other companies that should also benefit from growth in this area of activity. Although the large companies are well known because of their status as prime weapons systems contractors, many of the relatively smaller concerns also have an important place in this field.

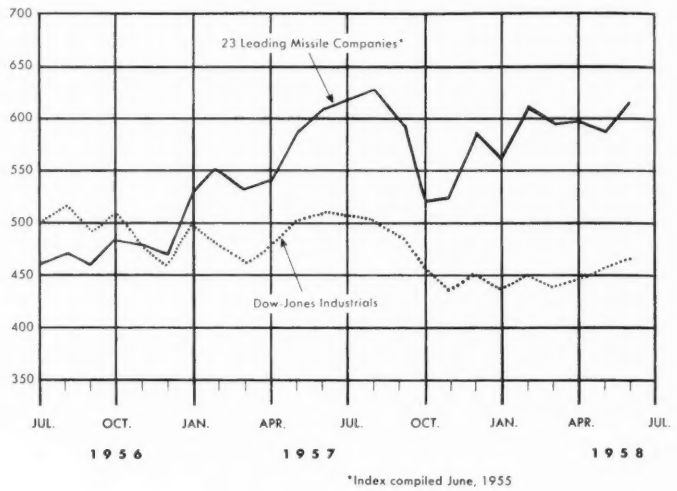
A relatively small company that should benefit from the great upsurge in rocket and guided missile production is Chromalloy Corp. of White Plains, N.Y. Although its principal revenue is derived from its gray iron castings business, the potential of the company lies in its exclusive licenses for a process originally developed in England. This process applies chromium to the surface of steel, iron, and certain nonferrous metals so that surfaces treated become comparable to stainless steels and other high alloy steels at greatly reduced material, machinery, and fabricating costs. Treating metals by this process results in extraordinary resistance to wear, abrasion, heat, and corrosion without materially affecting surface dimensions of the materials treated.

Chromalloy has made considerable progress in applying this process to such metals as molybdenum, cobalt and colombium and their alloys. The process has in all known tests exceeded by far the performance of any protective coating, giving molybdenum parts reliable protection in temperatures ranging up to 3000 F.

Recently, the company acquired exclusive rights to a new metallic diffusion process. This should enable the company to enlarge its field of activity to include gaseous diffusion of beryllium, silicon, aluminum, and other elements. Both processes should have tremendous applications in the rocket and missile field.

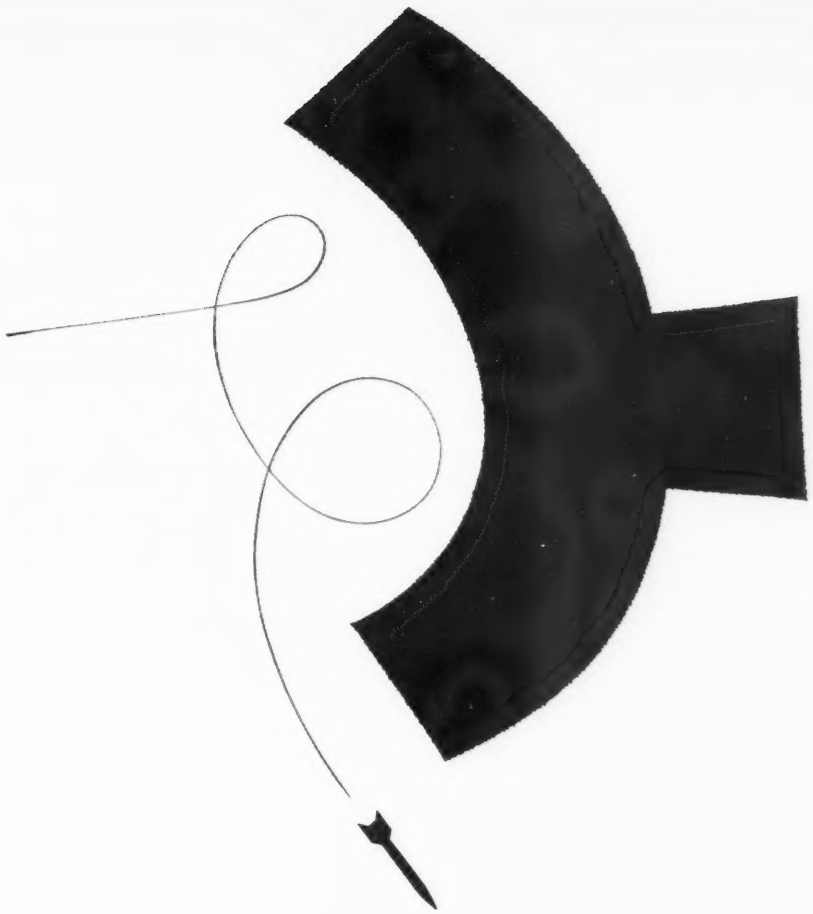
(CONTINUED ON PAGE 56)

THE MARKET AT A GLANCE



*Index compiled June, 1955

	June 1958	May 1958	% Change	June 1957	% Change
Dow-Jones Industrials	463	455	+1.8	505	−8.3
23 Missile Companies	620	589	+5.3	614	+1.0



MAKING MISSILES MISS...*TO SAVE YOUR LIFE*

Missile warfare may never come . . .

BUT IF IT DOES – then what?

Is there something we can do to stop, deflect or destroy an enemy missile screaming down from outer space – at a speed that staggers comprehension–carrying a warhead that can obliterate its target?

We've only a few minutes to act. Can we send an electronic bullet into its computing, calculating brain? Can we blind its radar eyes? Can we throw a meteroic roadblock in its path? Can we fool it into committing suicide?

The answers are found in secret devices and systems called "countermeasures"–designed to make missiles miss.

Electronic countermeasures. Other kinds, too

Many brilliant minds are working on the problem – including top scientists and engineers at IT&T who have been researching, devising, inventing...for more than 15 years. Today, no less than 156 engineers at one IT&T laboratory alone are working on countermeasures and nothing else.

This much can be told. A number of countermeasures exist today. Others are being perfected. Still others are being started from scratch–to be ready for whatever tomorrow may bring.

Many tools – many skills

Many tools are being used – radar, infrared, chemicals, others. Many skills are required – in physics, metallurgy, astronautics, as well as electronics. And thousands of IT&T technicians and artisans are working in these fields.

This is one of the big assignments the Department of Defense has asked IT&T to tackle. Guiding and controlling our missiles is another. Testing and launching them, too, and building communications between missile facilities.

The Air Force has even turned over to IT&T the all-important job of operating and maintaining the Distant Early Warning radar network in the Arctic, (the "DEW LINE").

Perhaps the missiles will never come. *But if they do* – countermeasures will be needed to make them miss. IT&T is working day and night to make sure the countermeasures will be ready.

IT&T

. . . the largest American-owned world-wide electronic and telecommunication enterprise, with 80 research and manufacturing units, 14 operating companies and 128,000 employees.

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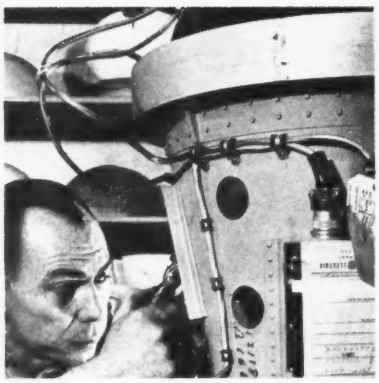
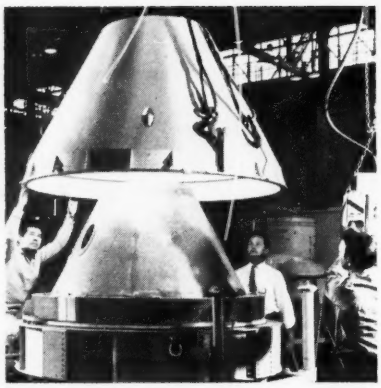




Checking Out the Atlas Nose Cone

Although the nose cone configuration itself is still classified, these photos give some indication of the size and complexity of the Atlas nose cone for which General Electric is prime contractor. At left, a technician checks data recovery capsule, designed to back up telemetry systems that may not be able to transmit through ionized gases, and that will be ejected before impact. Center photo shows the nose cone being repacked into its carrier case. At right, engineers study plans for mating the nose cone with the Atlas missile, shrouded behind a canvas windbreak in its gantry at Cape Canaveral.

Testing Giant Rocket Engines

(CONTINUED FROM PAGE 29)

strumentation switching automatically. Powering instrumentation with d-c was obviously advantageous from the standpoint of linear data reduction and rapid voltage calibrations with a minimum of manual work. The shops were built in conjunction with the stands to cut to a minimum machine tools for maintenance work, facilities for testing motors in preparation for firing, and equipment for removing and replacing all engine components.

Finally, the facility was to take as little land as was practical for safe and efficient operation of the area.

Meeting these goals has led to smooth operation of the facility. A request for a test, giving conditions for testing and data to be taken, goes to the Test Division and other appropriate operating groups, such as those handling instrumentation and data reduction. This request forms the basic guide for the test.

Work Goes Faster in Shop

Delivered to the shop of the appropriate test zone, the engine or component to be tested is inspected visually, undergoes preliminary tests, such as those for the functioning of controls, has instruments installed, etc. This work obviously goes faster in a shop than on a stand, it is out of the weather and it also keeps the stand free for testing proper.

Initial work done, the engine or component is installed in the test stand, all piping and electrical connections made, pressure tests of piping and circuit checks of instrumentation run, propellants loaded, and a final inspection of the stand and engine made by the technician leadingman and test engineer. Check lists cover all work during engine installation and test-stand servicing, and a central planning group, which reviews operations and tests in the light of the check lists, maintains test operation standards.

Fifteen minutes before the test, the crew leaves the stand for shelter, a voice warning is given and the test engineer takes over, directing prefiring activities and manning the firing console that controls engine functions. Another engineer mans the common console for controlling test stand and zone equipment. A "10-minutes" warning brings intermittently flashing yellow lights and rings bells throughout the test zone; a "5 minutes" final warning sends everyone in the test zone to shelter; and a siren sounds as a "30-second" warning and continues to firing time minus 2 seconds.

Members of the crew follow critical parameters on strip-chart recorders in final preparations and during the test itself. Instrumentation engineers stand by the firing console to give aid in the event of last-minute difficulties. Closed-circuit television covers the engine and the stand during the test, as does an observer some 900 yd behind the stand. When television and the observer's report show all normal after a test, an "all clear" is sounded for work in the zone other than on the stand used. "All clear" for the stand follows its inspection by the crew.

Firm schedules made at the beginning of each day govern testing and switching of controls from one stand to another. The big job of changing instrumentation from one stand to another can usually be done in an hour-and-a-half, thanks to the provisions designed into the test zone. The general procedure in scheduling work for a three-stand test bed is to set up instrumentation for a test in one stand and to have another stand all ready for a test should a malfunction or some other mishap necessitate shifting hardware from the first stand to the other.

Preventive Maintenance Program

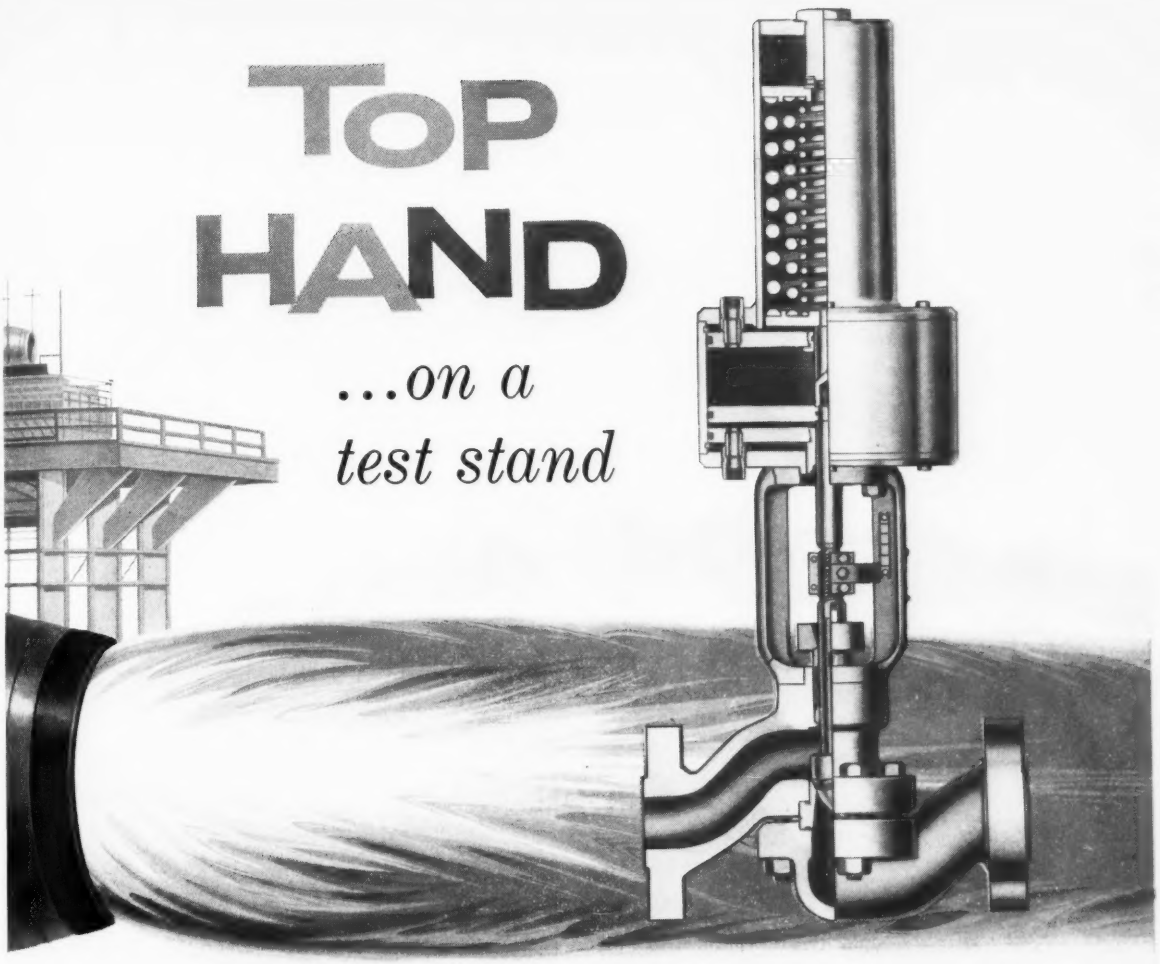
This scheduling is supported by a program of preventive maintenance, which sees that all functional valves, regulators, etc., are checked regularly to prevent minor hitches in equipment from disrupting the schedule.

Data sheets with the test engineer's remarks are prepared on each static firing and go to all interested groups. In addition, trouble reports covering component failures, servicing difficulties, etc., are prepared to supplement the data sheets following any unusual occurrence.

The compactness of the test zone and interrelation of the stands and controlling and servicing equipment make assignment of crews and engineers from test to test efficient and flexible. These people soon acquire experience with different motors and various kinds of testing. This experience can be channeled to push testing on a crash program without special training or overwork of crews, and

TOP HAND

...on a test stand



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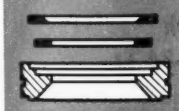

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SENSITIVITY	±20 mv nominal
TEMPERATURE RANGE	−65° to +250°F
ACCELERATION	Withstands 200 g's
CONSTRUCTION	416 stainless steel
SIZE	0.220″ x 0.475″ diameter
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RECOGNIZED LEADERS IN GALVANOMETERS—
TELEMETRY, PRESSURE AND VIBRATION INSTRUMENTATION

also serves to lighten the burden of absences and duty shifts.

One reason that flexibility of crews and engineers is important is that the staff for a facility of this kind is large even with flexibility, and personnel problems mount with the size of the organization. Also, the flexibility needed for the large variety of test work demanded of the engineer helps to stimulate his investigative powers and to renew the edge of his skills and interest, which can atrophy when developmental testing shifts to production testing, with its somewhat uninspiring repetition.

The close operating limits and high degree of reliability required of rocket engines dictates that for some time to come a very large portion of any engineering development and production activity in this field must include a well-equipped, well-staffed test organization to serve as the final proving agency for the end product before it is trusted to push a high priced vehicle into space.

Based on a paper presented at the ARS Semi-Annual Meeting at the Statler Hotel, Los Angeles, Calif., June 9-12, 1958.

British Blue Streak IRBM Nearing Systems Test Stage

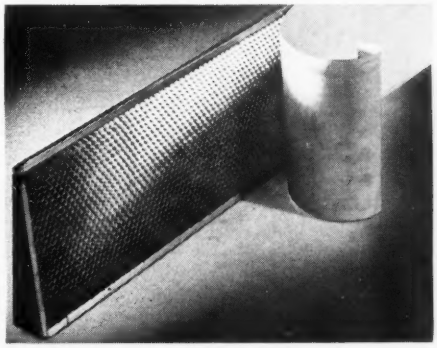
The British Blue Streak IRBM, designed for underground launching, has undergone tests of its major components and is now being readied for systems testing. Firing trials of the complete weapon, which can carry a thermonuclear warhead over a range of several thousand miles, and will be fired from underground bases, will take place at Woomera, Australia.

Prime contractor for the project is De Havilland Propellers, Ltd. Associated main contractors are De Havilland Aircraft, Ltd., presumably responsible for airframe construction and final assembly; Rolls-Royce, Ltd., powerplant development and production; Sperry Gyroscope Co., Ltd., missile guidance system and associated avionic parts; and Saunders-Roe, Ltd.

Sputnik II Length Estimated at 74-84 Ft.

Measurements made from photographs taken of Sputnik II as it passed within 200 miles of Patrick AFB, Fla., indicate the satellite was 79 ft long, plus or minus about 5 ft. The photos, taken by RCA Service Co. personnel with the AF Recording Optical Tracking Instrument (ROTI) built by Perkin-Elmer Corp., also showed the satellite tumbled end over end in its flight, in direct contrast to the Army's Explorer I, which was spun prior to launch to prevent such tumbling.

Special Solar Skills for Advanced Systems



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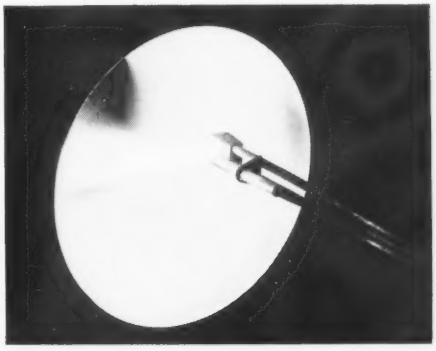
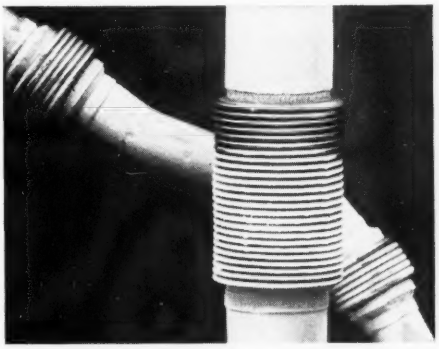


PROTECTIVE COATINGS. Solar research and development in advanced metallurgy has produced a family of high-temperature protective coatings far ahead in the field.



EXPANSION JOINTS. Solar produces the largest array of expansion joints in the world, including complete ducting systems for aircraft, missile, nuclear and other applications.

HIGH-TEMP. BRAZING. Using hard-to-work metals and high-temperature alloys, Solar brazes stronger, lighter systems components in specially designed heat-treating furnaces.

Solar offers proven systems capabilities

Systems capabilities at Solar embrace the design, development and production of airframe, propulsion, ground support, guidance and control systems. Responsibility for Solar's systems program is centered in a team of experts experienced in the many sciences related to systems technology—from basic design to highly-precise experimental, prototype and volume production. And underlying Solar's systems capabilities is a backlog of more than thirty years of proven leadership in high-temperature metallurgy, aerodynamics, thermodynamics, combustion research and others.

Complete manufacturing and test facilities are also available for your important systems program. For detailed information about Solar's systems capabilities, or about any of the areas mentioned above, write to Dept. F-33, Solar Aircraft Company, San Diego 12, California.

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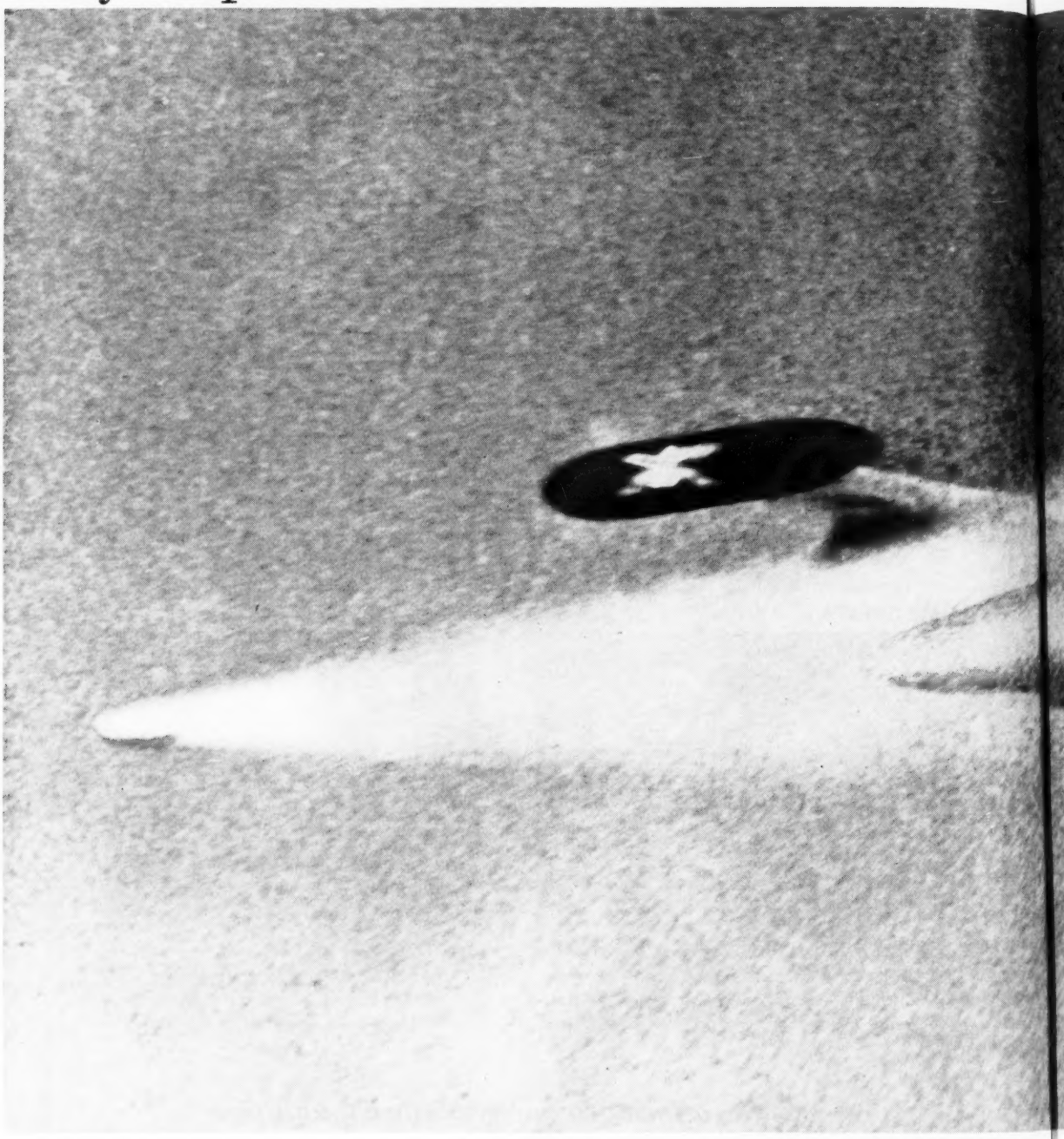

One-shot rocket blasts entire attacking fleet

Early last summer at Yucca Flats, Nevada, military observers saw the first demonstration of a new concept in defense weapons—the Douglas *Genie*...

Today this formidable nuclear missile is on operational duty with the Air Force—is the primary air-to-air defense missile in the U.S. arsenal.

The stubby *Genie* rocket is compact enough to be handled by a fast interceptor – yet can knock out an entire fleet of bombers with a single hit or a near miss. Designed primarily for use against high altitude jets, *Genie's* atomic warhead can be fired without radioactive fallout. It is thus usable against

*** Defensive Systems**—Enemy aircraft trying to break through America's air defenses now face fast interceptors like the Northrop F-89 *Scorpion* carrying such powerful armament as the Douglas *Genie*. This atomic missile can destroy an attacking formation with even a proximity explosion.

sneak attacks over our own or friendly territory.

Rapid development of *Genie* from design and test stages into quantity production is typical of the speed and thoroughness of the Douglas approach. To date Douglas has produced almost twenty thousand experimental and operational missiles for the Army, Navy and Air Force in *all four major categories:* air-to-air, air-to-surface, surface-to-air and surface-to-surface.

Depend on

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first in Missiles

ARS news

Fifth Nuclear Congress Set For Cleveland April 5-10

Preliminary plans for the Fifth Nuclear Congress, to be held next April 5–10 at the Cleveland Auditorium, have been announced by the Engineers Joint Council. As in the past, the congress, which will be sponsored by a number of engineering societies, including ARS, will be made up of four parts: The Nuclear Engineering and Science Conference; the Hot Laboratories and Equipment Conference; the Atomic Energy Management Conference; and the Atom-fair, at which nuclear equipment will be on display.

Engineers and scientists who would like to present technical papers during the congress are invited to submit outlines before Oct. 1. Summaries of 300–500 words should be sent to the ARS executive secretary, 500 Fifth Ave., New York City.

Awards Committee Named

The ARS Awards Committee for 1958 has been appointed by Kurt Stehling of NRL, Chairman. Members of the committee are: Wernher von Braun, ABMA; C. W. Williams, Chrysler Missile Div.; Bob Wehrli, Robertshaw-Fulton; Vincent Cushing, Armour Research Foundation; S. K. Hoffman, Rocketdyne; Roy E. Marquardt, Marquardt Aircraft Co.; and Frederick C. Durant, Avco Research Lab.

ARS President Visits Holloman Section

Flanking ARS national president George P. Sutton (second from right) at the Holloman Section's annual president's reception and dinner are (left to right) Knox Millsaps, section president; Maj. Gen. W. E. Laidlaw, Commander, White Sands Proving Ground; and Maj. Gen. L. I. Davis, Commander, AF Missile Development Center.

ARS Adds 2165 Members, New Corporate Member

ARS has added more than 2000 new members since the first of the year, with the May tabulations not yet complete. The count, as of May 23, was 2165.

Metallurgical, Inc., Minneapolis, Minn., active in the field of commercial heat treaters of missile motor chambers, recently became a corporate member of the Society. Representing the company in ARS are A. T. Ridinger, president; L. Ridinger, vice-president; and Gordon Moline, Charles S. Olson, and William S. Lawson, sales representatives.

AMERICAN ROCKET SOCIETY

500 Fifth Ave., N. Y. 36, N. Y. Pennsylvania 6-6845

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High-Atmosphere Conference Set for El Paso Oct. 14-16

The New Mexico-West Texas Section of ARS and the American Meteorological Society will hold a conference on the high atmosphere in El Paso, Tex., Oct. 14–16. The conference will deal with all atmospheric phenomena occurring above approximately 100,000 ft.

Liquid Rocket Committee Members Appointed by Lee

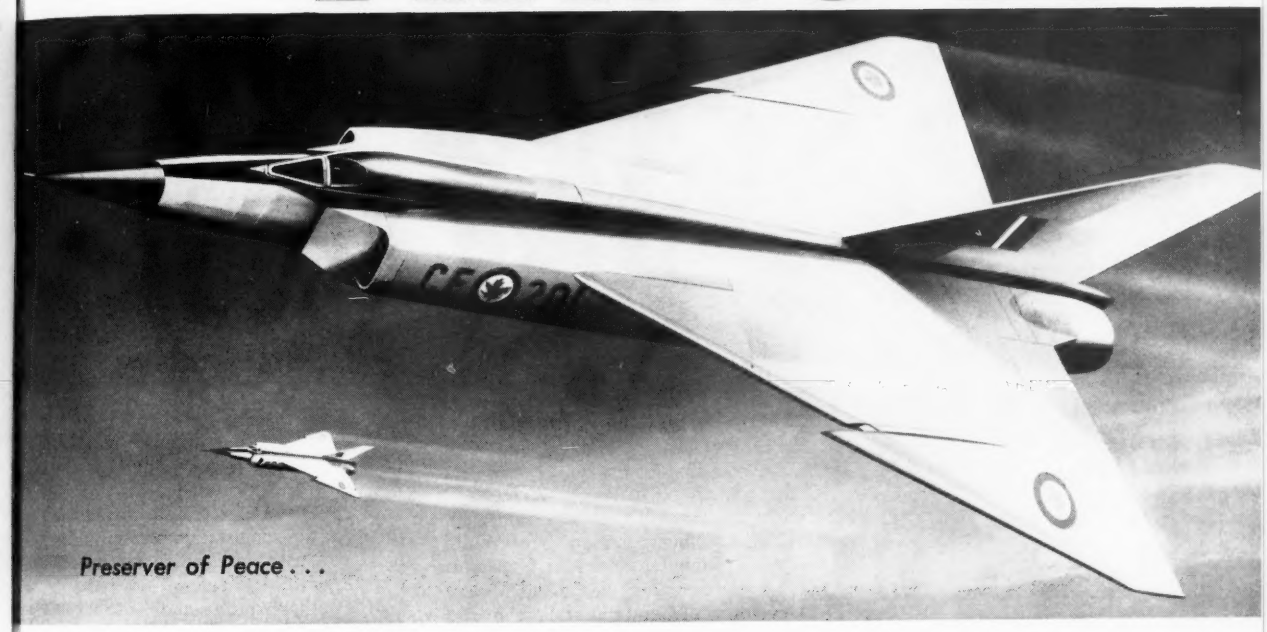
Y. C. Lee of Aerojet-General Corp., Chairman of the ARS Liquid Rocket Committee, has announced the makeup of the committee. Members appointed to the committee are: Robert M. Bridgforth, Boeing Airplane Co.; Robert F. Rose, JPL; Clair M. Beighley, Aerojet Liquid Rocket Plant; and Robert S. Levine, Rocketdyne.

Two Awards for ASTRO

ASTRONAUTICS has won two awards in *Industrial Marketing Magazine's* 20th annual Editorial Achievement Competition for Business Publications, the only magazine in the aviation and astronautics field to be so honored. The awards are a first place plaque in the best graphic presentation classification and a certificate of merit in the best single issue classification in the Class, Institutional and Professional Publication category of the competition.

The awards were presented to ASTRONAUTICS Editor Irwin Hersey during the National Industrial Advertisers Assn. annual conference in St. Louis the first week in June.

AVRO ARROW



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DEFENSE ELECTRONIC PRODUCTS

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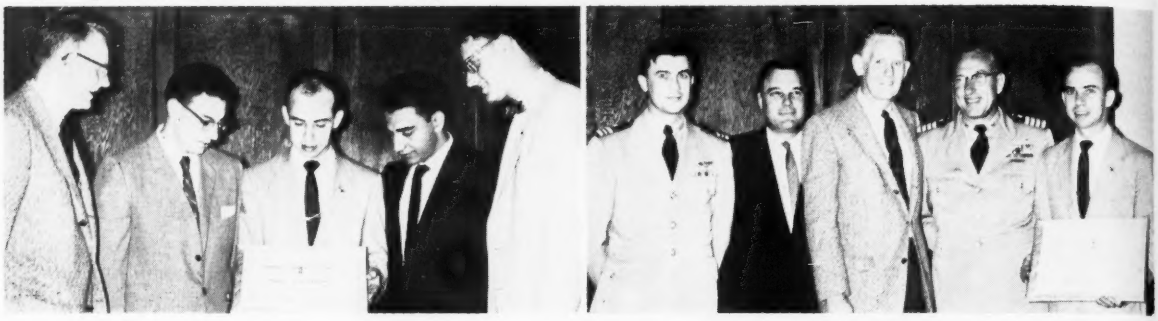
Big Day for Florida Student Chapter as Charter Is Presented



Left, admiring the new U. of Florida student chapter charter are (left to right) David T. Williams, faculty adviser; Herb Eisenberg, recording secretary; Richard Jackson, president; Spyros Magliveras; and Marvin Moss, treasurer. Right, Lt. Comdr. E. L. Peutrowski; Richard Yordy of Pan American; Dr. Williams; Capt. Robert F. Sellars, Director of Navy Test, AFMTC, and president of the Florida Chapter, who presented the charter, pose with Jackson.

Sloop Heads ARS Propellants And Combustion Committee

John L. Sloop, chief of the Rocket Branch, NACA Lewis Flight Propulsion Laboratory, has been appointed

John L. Sloop

Chairman of the ARS Propellants and Combustion Committee. He succeeds John Tormey of Astrodyne, who has served in the post for the past two years.

SECTIONS

Alabama: Josef Boehm, chief of the electromechanical engineering branch of the guidance control lab at ABMA, was the guest speaker at a recent meeting of the section. His topic was "Unnatural Earth Satellites."

Columbus: Arnold Bass of the National Bureau of Standards was the guest speaker at the May 6 meeting of the section. Dr. Bass gave an excellent talk on "Frozen Free Radicals," and discussed the progress made in this field to date. He began with an explanation of the term and of the many ways in which frozen free radicals may be obtained, and also discussed their properties at length with the aid of slides and films, and showed the energy levels available for some. He ended his talk with a demonstration of the effect of fluorescence in some free radicals.

At the same meeting, a discussion arose over the new Columbus ordinance banning the firing of home-made rockets, and members were asked for suggestions on how to channel the interest of youngsters into safer fields.

—Dean L. Pendleton

Holloman: A regular monthly meeting of the Holloman Section was held May 13 in the ballroom of the new Officers' Club at Holloman AFB. President Knox Millsaps opened the after-dinner portion of the meeting with the introduction of Maj. Gen. W. E. Laidlaw, commander of White Sands Proving Ground; Maj. Gen. L. I. Davis, commander of the AF Missile Development Center at Holloman; and Comdr. E. W. Bode, representing the commander of the Navy detachment at White Sands.

President Millsaps then introduced the honored guest and speaker for the evening, the ARS national president, George P. Sutton of Rocketdyne, who spoke on astronautics and politics.

At the beginning of his speech, he pointed out that the points of view on space flight are numerous. He clarified the differences between several of these points of view, namely, the military point of view, the point of view of nonmilitary government agencies, of President Eisenhower, and lastly, of the scientists and of the average citizen.

On the subject of the military point of view, he ran down current Army, Navy, and AF programs and their relationship to the future of space flight. He commended Roy Johnson for his very effective administration of the new agency known as ARPA, stating that ARPA had made a real beginning on setting up some sort of order within the maze of astronautical programs and would-be programs. He also discussed at some length President Eisenhower's suggestion for a new space agency to be known as NASA.

He then gave a rather lengthy and careful review of nearly all of the interested organizations which have in one way or another become associated with space flight and its problems. He mentioned the interest of NSF, AEC, the ARS, and of a number of important committees in Congress.

Those present were encouraged to hear that President Sutton, who has been in direct contact with Congressional committees, believes our representatives in Congress are taking this phase of their legislative responsibility most seriously and are doing a very fine job with it.

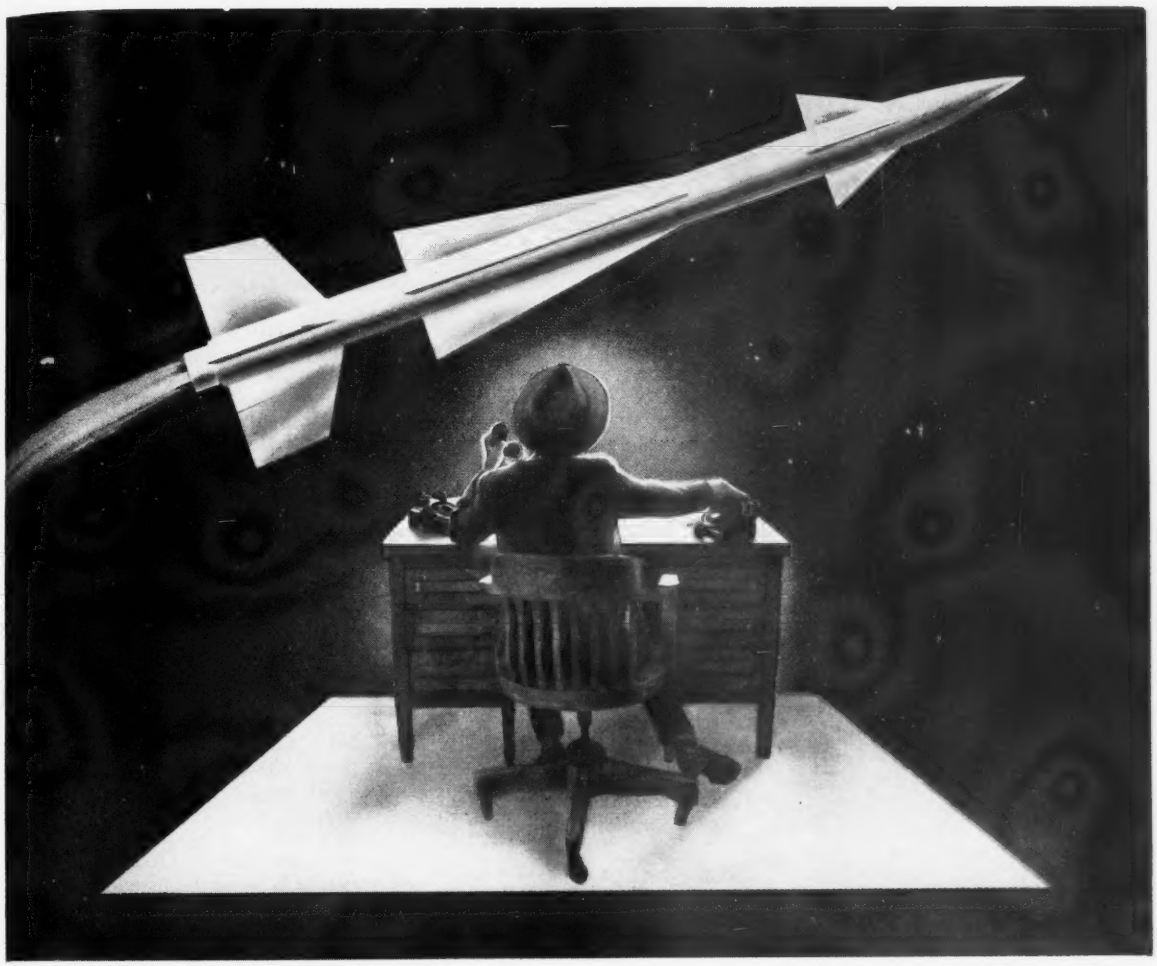
It is perhaps quite significant that he feels the administration and leadership of both parties in Congress believe rather definitely that space-science development should be controlled by an essentially civilian agency.

He closed his talk with a discussion of the benefits we may expect from space flight, noting that the life-or-death question of world peace may be answered by our accomplishments in this field.

—Lt. Col. H. L. Gephart

Indiana: "We are now on the threshold of space exploration." These words keynoted the address of Maj. Gen. Marvin C. Demler, AF Deputy Commander for Research and Development, which highlighted the ninth annual banquet of the Indiana Section.

Gen. Demler emphasized that we are not exploring space out of curiosity, but rather that we are driven by a need for survival and the realization that we must excel over those who would seek to destroy us. His address was complemented by the showing of



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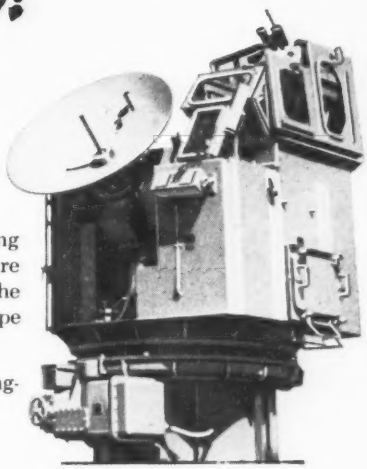

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films depicting the countdown and launching of an Atlas ICBM and of various AF missiles in action.

The general was introduced by M. J. Zucrow, professor of gas turbines and jet propulsion at Purdue U. and ARS national board member. The welcoming address was delivered by H. L. Solberg, head of the mechanical engineering school at Purdue, who was introduced by section president Donald Emmons.

—Alfred C. Pinchak

Maryland: Joel M. Jacobson, vice-president and general manager, Aircraft Armaments, Inc., was the guest speaker at the May dinner meeting of the section. His topic was "Cost Control in R&D Engineering."

New York Metropolitan: Louis A. Witten of RIAS (Research Institute for Advanced Studies), a Martin Co. subsidiary which has been active in the field of gravitational research, was the guest speaker at the May 23 meeting of the section. The meeting drew a good turnout of some 150 members and guests, all anxious to hear Dr. Witten's discussion of current work in this area.

In introducing Dr. Witten, section president Len Weiner expressed the hope that gravitational research would lift the burden of the propulsion engineer by promising "some elegant, and legitimate, mode of levitation." Dr. Witten cheerfully replied by saying he hoped good progess was being made in nuclear propulsion, and turned to a review of gravitational concepts and the limited means available for studying gravitational fields through experimentation, such as making measurements of the ratio of inertial to gravitational mass. It was no solace to the astronauts present to learn that most of the present serious work in the field centers on attempts to apply quantum mechanics to the general theory of relativity.

ARS Members Get Close Look at Regulus

Left to right, ARS members R. S. Atkinson, Ted Edlebaum, E. E. Hendren, and J. N. La March examine the air scoop of the Regulus II missile in the course of an inspection tour of the Chance Vought Dallas plant held in conjunction with the recent ASME-ARS Aviation Conference in that city.

New Mexico-West Texas: Paul Merrill of the Palomar Observatory was the guest speaker at a joint meeting of the section and the New Mexico A&M chapter of Sigma Xi on May 9. Dr. Merrill's topic was "From Atoms to Galaxies." The May 21 meeting at the Las Cruces Country Club was addressed by Harold W. Ritchey, vice-president and technical director, Thiokol Chemical Corp., and ARS national board member. Dr. Ritchey spoke on the subject of solid-propellant rockets. The June 26 meeting was addressed by James Warwick of the High Altitude Observatory, Boulder, Colo., who discussed the tracking of the Sputniks by the observatory.

—Russell K. Sherburne

Northeastern New York: Andrew G. Haley, president of the International Astronautical Federation and ARS general counsel, was the guest speaker at the section's May dinner meeting. His topic was "Astronautics in Europe."

Pacific Northwest: More than 170 members and guests attended the first annual Spring dinner meeting of the section. Among those in attendance were a number of members from the U. of Washington student chapter.

Brooks T. Morris, executive engineer, Marquardt Aircraft Co. and Chairman of the ARS Ramjet Committee, was the guest speaker. His topic was "The Age of Ramjets," and in his talk he traced the development of the ramjet, pointing out that recent missile and test vehicle flights indicate the age of the ramjet has arrived.

Michael Maes of the U. of Washington presented the paper for which he received first prize in a recent ARS-sponsored student paper contest at the meeting, and, received his prize, as did Gilbert C. Tsao, who won the second prize in the contest. New officers of the University student chapter were introduced by R. E. Street, professor

on the calendar

1958	
July 8–11	IAS National Summer Meeting, Ambassador Hotel, Los Angeles, Calif.
Aug. 5–6	**Space Exploration Meeting sponsored by ARS, IAS, San Diego Sections.**
Aug. 7–15	Heat Transfer Course given by Heat Transfer Lab. of the Mechanical Engineering Dept., U. of Minnesota.
Aug. 13–21	10th Assembly of the International Astronomical Union at Moscow.
Aug. 18–23	Systems Engineering and Missile Operations Seminar, Pennsylvania State U., University Park, Pa.
Aug. 25–30	**Ninth Annual Congress of International Astronautical Federation, Amsterdam, The Netherlands.**
Sept. 1–6	1958 Farnborough Flying Display and Exhibition, Farnborough, England.
Sept. 3–5	1958 Cryogenic Engineering Conference, MIT, Cambridge, Mass.
Sept. 8–13	First International Congress of Aeronautical Sciences, sponsored by IAS, Madrid, Spain.
Sept. 15–18	**ARS Meeting, Hotel Statler, Detroit, Mich.**
Sept. 22–24	IRE National Symposium on Telemetering, the American Hotel, Bal Harbour, Miami Beach, Fla.
Oct. 13–15	National Electronics Conference, sponsored by IRE, AIEE, EIA, Hotel Sherman, Chicago.
Oct. 14–16	**ARS New Mexico-West Texas Section and American Meteorological Society High Atmosphere Conference, El Paso, Tex.**
Nov. 10–12	AF School of Aviation Medicine-Southwest Research Institute Space Symposium, Hilton Hotel, San Antonio, Tex.
Nov. 17–21	**ARS 13th Annual Meeting, Hotel Statler, New York, N.Y.**
1959	
April 5–10	Fifth Nuclear Congress of Engineers Joint Council, Cleveland Auditorium, Ohio.

of aeronautical engineering, the group's faculty adviser.

—Michael Guidon III

Southern California: A highly successful night field trip to the Propulsion Field Lab of Rocketdyne in the Santa Susana Mountains, about 35 miles from downtown Los Angeles, marked the April meeting of the section.

Following a briefing and the showing of short films about the facility and about Atlas and Thor launchings, the 170 section members in the party donned protective headgear and watched the testing of two gas generators. When the test cells had been declared safe, the party was escorted through the component test laboratory for a look at the plumbing and instrumentation, as well as several turbopumps awaiting testing.

The party was then driven through the picturesque landscape of great tumbled rocks to one of the several test areas where a firing was scheduled. Each area has three or four stands anchored to the bedrock and associated with a control blockhouse.

The first rocket engines to be fired were two vernier engines. These were gimbal mounted and went through an involved gimballing program during the test. The stability of the brilliant flame was particularly impressive during the run of several minutes.

After this small engine test, the party boarded the buses to visit another test area. Here, a large engine was ready for testing. This one was without a turbopump and was fed by pressurized gas. Commencing with a brilliant flash and earth-splitting roar, the exhaust jet speared diagonally across the bowl of the test area in a most impressive display.

A second large engine test was witnessed at another test area. Spouts of liquid oxygen from the engine rythmically gushed from the stand and filled the bowl-shaped depression with an eerie white carpet of condensation, forming a backdrop for the firing. An initial flash and bang dispersed the vapor as the engine roared into life. Some members involuntarily drew back as an igniter shot across the test area like a tracer bullet, a vanguard for the powerful jet which shafted through the blackness of the night.

The other big engine was mounted vertically, with the flame going into a flame chute. When one of these flame chutes was later inspected at close hand, we got a better perspective of the engine which had been tested on the hill. Later, one of the control blockhouses was inspected.

All who attended appreciated the efficient organization of the tour. Since no special tests were put on for the group, and a normal evening's tests were conducted, Rocketdyne is also to be congratulated on the fact that its engines performed so faultlessly for the ARS members.

—Eric Burgess

Southern Ohio: New officers of the section are S. N. Suciu, president; George C. Szego, vice-president; H. M. Weber, treasurer; and Miss M. C. Pope, secretary. All are with the GE Flight Propulsion Lab in Cincinnati.

St. Louis: Richard H. Frost, vice-president of Stanley Aviation Co., was the guest speaker at the May meeting of the section, delivering a very interesting talk on "Supersonic Aircraft Escape Systems." The development of the supersonic ejection seat and capsule was admirably described in a series of slides and in a sequence of test shots from rocket sleds, and complemented by the personal experiences of the speaker.

Rocketdyne Puts On a Show

Members of the Southern California Section had an opportunity to get a close look at the operation of a large rocket engine test facility during a recent night field trip to the Rocketdyne Propulsion Field Lab. Above, the group watches test firing of a large engine, while below ARS members inspect one of the control blockhouses.

Members of the section were urged at the meeting to make known their suggestions for future activities to section president P. W. Godfrey or program chairman R. A. Cooley in time for them to be included in the group's Fall program.

—James N. Holsen

STUDENT CHAPTERS

Academy of Aeronautics: Felix R. Giacini Jr. has been elected president of the chapter, with Lucien Joly elected vice-president and treasurer, and Jesse M. Schneider named secretary. David M. Terry continues as faculty adviser. The chapter is now in the process of forming an evening division.

U. of Florida: Newly elected officers of the chapter are Marvin Moss, president; William Schilling, vice-president; Herbert Eisenberg, recording secretary; Spyros Magliveras, treasurer; and Lawrence Butterfield, corresponding secretary. David T. Williams continues as faculty adviser.

T. S. George of the university's

At Indiana Section Annual Banquet

Left to right, Maurice Zucrow of Purdue U.; Maj. Gen. Marvin C. Demler, guest speaker; and Donald L. Emmons, president of the Indiana Section, examine a model of a large liquid-propellant engine at the ninth annual banquet of the section.

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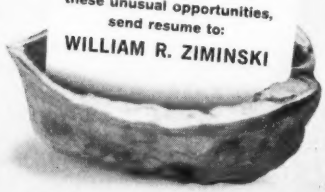

FAIRCHILD GUIDED MISSILE DIVISION
Wyandanch, Long Island

electrical engineering department presented a very interesting talk on "Problems Connected with the Testing of Long-Range Missiles" at a recent meeting.

—**Herbert Eisenberg**

U. of Virginia: Charles Green was elected president of the chapter at the May 15 meeting. Other new officers are: Vernon Wagner, vice-president; Stuart Croll, secretary; and Reid Pendleton, treasurer.

CORPORATE MEMBERS

Thompson Products will publicly unveil for the first time the full scale missile systems ground test facility is operates for the Air Force at Inglewood, Calif., during a tour sponsored by the Western Electronics Show and Convention next month. Electronic data processing and acquisition systems with an 800-channel capability will be shown during the tour.

Servomechanisms, Inc., has consolidated its two West Coast Components divisions, the former Magnetics Div. and Vacuum Film Products Div., into a single unit, to be known as the Special Products Div.

General Electric's Heavy Military Electronic Equipment Dept. is building a new ballistic missile radar system test facility at its Systems Center in Industrial Park, Syracuse, N. Y. It is slated for completion late this summer.

Missile Market

(CONTINUED FROM PAGE 42)

To broaden its activities in this field, Chromalloy also plans to acquire Propellex Chemical Corp., which makes rockets fuels and chemical explosives. One Propellex development thus far has been designed for commercial use. This item, a refillable actuator, is for emergency operation of aircraft landing gear. Small enough to fit in the palm of your hand, the actuator supplements the hydraulic unit and feeds compressed gas directly into hydraulic lines. (Chromalloy Corp.: 1957 sales, $4.3 million; earnings per share, $0.42; dividend, none; capitalization, 491,000 common shares, traded American Stock Exchange.)

Another relatively small unit working for the defense effort is Sanders Associates of Nashua, New Hampshire. This company originally started life as a strictly research and development organization. Through its research work in missile systems, Sanders can, today, be put into the manufacturing class as well as maintaining its research and development role.

Sanders believes that it was the first to develop successfully the subminiature features of its subminiature rate gyroscopes for use as the control and stabilization elements in both missiles and aircraft. These devices sense the speed of rotation of the missile, aircraft or radar system in which they are installed and generate electrical signals which can be used for control.

Other products being produced by the company for use in missiles are a line of servo control valves and specialized instruments and components. Sanders which produces many other products for defense might be considered to have been born of the missile age. (Sanders Associates: 1957 sales, $5.6 million; earnings per share, $0.99; dividend, $0.08; capitalization, 253,776, traded over-the-counter.)

Financial Briefs

June 17 was an extremely significant day for investors in the missile industry. This was the day on which Ira Haupt & Co. started offering shares to the public of a new mutual fund, the Missiles-Jets & Automation Fund, Inc. At least 30 per cent of this fund's capital must be invested in the "missiles-jets," although a much greater percentage than this is planned.

Administering the fund will be an outstanding group of men associated with the missile and/or the investment field. Chairman of the board will be Theodore von Kármán, while Andrew Haley will serve as president. The firm of Templeton, Dobbrow & Vance will act as investment counselors to the fund. Full details are contained in the fund prospectus, which is available from any stockbroker.

Market Letter Gleanings

North American Aviation—". . . selling at around 10 times current earnings and at 8.5 times average earnings of the past five years, we recommend the stock for income (5.5 per cent return) and for long-range capital gains." (Purcell & Co.)

"We recommend *Marquardt* as speculatively attractive for longer term appreciation." (Goodbody & Co.)

Bendix Aviation—"The common stock selling at a substantial discount from its 1957 high is currently attractive for long term growth." (Thomson & McKinnon)

General Tire—". . . the stock looks attractive for those seeking longer term appreciation." (Robert Timpson & Co.)

Lockheed—"We regard the stock as

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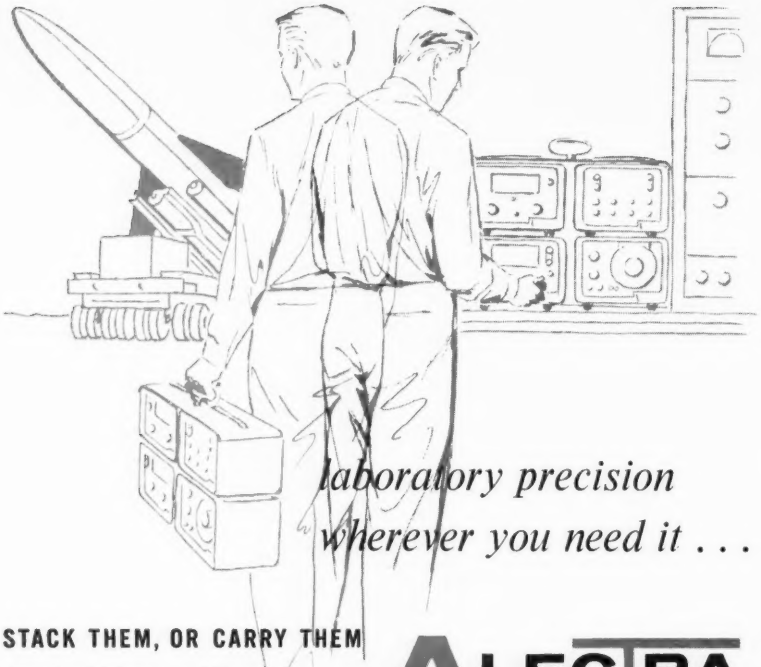

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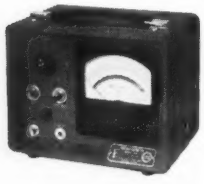

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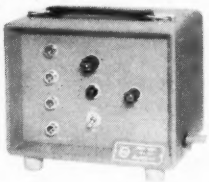


an attractive speculation for the longer term." (Reynolds & Co.)

". . . we feel *Emerson Electric's* shares, selling at a reasonable 10.3 times earnings, offer sound growth prospects within a dynamic industry. Purchase is recommend." (Eisele & King, Libaire, Stout & Co.)

American Potash—"Speculative commitments expected to prove rewarding in the period ahead." (Fitch)

Martin—"Stock for action . . . on the basis of promising prospects further ahead and the company's well-situated position in the missile field . . . the shares appear to have worthwhile appreciation possibilities." (Standard & Poor's)

Nondestructive Tests

(CONTINUED FROM PAGE 33)

a part for dimensional inspection.

A second major consideration in the intelligent use of nondestructive testing lies in the interpretation and utilization of test data. There are many examples of spurious indications which make such testing difficult. In the ultrasonic testing of precipitation hardening steels, for example, there are reflections from grain boundary precipitates, while the early development of magnetic particle inspection was plagued by a long and sometimes painful period of educating operators to learn whether indications were real or false. The mere fact that an indication is judged to be real does not end the story. In fact, quality control actually begins only at this point.

Must Find Origin of Condition

It is the job of the nondestructive test engineer to isolate the origin of this indication to the foundry, heat treatment, machine shop or design so that appropriate remedial action can be taken. This means, then, that the radiographer who is reading film on castings must not only have an understanding of the engineering design requirements and the principles of radiography, but must also have an appreciation of foundry techniques and practices so that he can completely evaluate the film.

In castings, indications may be due to defects originating from melting stock, foundry sand, molding practice, core making practice, fluxing, gating, pouring and a wide variety of other causes which are only too well known to the foundryman. The mere statement that a part is not acceptable accomplishes little. Indeed, it is the philosophy of isolating the origin of the defect and taking remedial action at the source which characterizes

modern quality control.

There is sometimes the misconception that a hard-hitting quality control and test program is a luxury. However, experience has shown that cost reduction can actually be achieved at the same time that quality is improved. This seemingly paradoxical situation comes about through detailed analysis of design, manufacturing and processing, and by taking remedial action at the source of the problem.

This point can be illustrated with a one-year rejection and price history of a supplier of investment cast turbine blades. At the initiation of a quality improvement program, there was considerable skepticism in some quarters as to whether the high standards which were set could be achieved at any price. As may be seen in the graphs on page 33, rejection rates were reduced from a high of 34 per cent to less than 10 per cent in a year's time. Concurrent with this decreased rejection rate, cost per unit was reduced to 20 per cent of the original price, as shown in the lower graph.

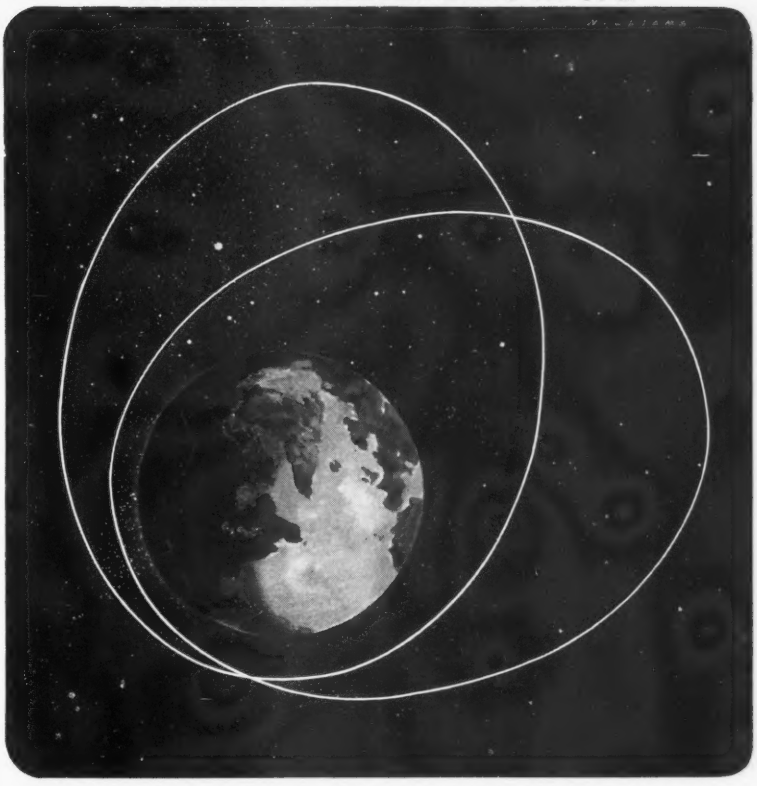
The success of this undertaking may be attributed to the fact that a well-planned quality control program was instituted, and that a vital part of this program was the judicious selection of nondestructive tests and close liaison between quality control engineers and the supplier foundry.

Followup Program Withdrawn

Although initially there was intensive quality control followup, it has been possible to withdraw a substantial part of this support so that the overall expenditure of time and effort is considerably less than before institution of this program. The costly practice of having to reject machined or assembled components for casting flaws which could have been observed under the proper conditions at an earlier stage no longer exists. This, then, is the goal of modern quality control—assuring reliability at low cost.

In summary, it is evident that in view of the complexity of engine and missile systems, and the pressure of accelerated research and development programs, the quality control engineer has a monumental task in assuring the designer that his hardware will fulfill design intent. This can be accomplished by a careful choice of test programs, and the cost can be reduced considerably by the educated application of nondestructive testing. This calls for the closest liaison between manufacturing, engineering and quality control, since a design of greatest reliability will not consistently succeed unless it is complemented by a strong quality control program.

NOTABLE ACHIEVEMENTS AT JPL



NEWS FROM OUTER SPACE VIA EXPLORER I AND III

Since the successful launchings of the Explorer I and III Satellites under the joint cooperation of the Army Ballistic Missile Agency and JPL, literally, bales of information on conditions outside the earth's atmosphere have been transmitted earthward from both satellites.

This information on cosmic ray activity, micro-meteorite density, and radiative heat flux is providing valuable new and accurate data of immense value to scientific research. Explorer III with its more sophisticated instrumentation is producing more complete data than Explorer I. This is partly due to the wider range of altitudes traversed by the orbit of Explorer III, but principally due to the presence in Explorer III of a tape recorder. Designed by Dr. Van Allen of the State University of Iowa it is no larger than a cigarette package and is capable of transmitting two hours of collected cosmic ray information in a space of five seconds.

The Laboratory is proud to have been chosen by the U.S. Army to spearhead this vital activity and to acknowledge the highly constructive efforts of many individuals and organizations who have cooperated with its own staff.

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Includes design of solid propellant rocket components, launching and handling equipment, cartridge actuated devices, and other advanced hardware.

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To establish a group for development of semi-conductors and electromechanical devices for commercial markets.

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From the patent office

BY GEORGE F. McLAUGHLIN

Moisture Protection for Missile Optical Systems

HOMING bombs or missiles often encounter varying temperature conditions which may fog the optical system. Since water is opaque at the infrared wavelength used in a heat homing missile, even small quantities of condensation cannot be tolerated. A system which has been patented protects missile optical surfaces from moisture without reducing sensitivity of the optical system. This is accomplished by enclosing the system in an airtight container in which the air is dried, and by using windows made of material highly transparent to infrared radiations.

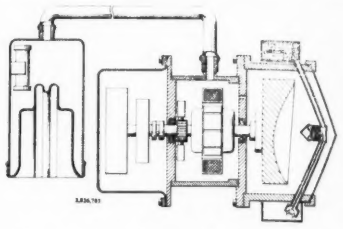
The bolometer, or IR-sensitive element, is made up of several thin nickel strips, supported side by side in a perpendicular plane by spring strips of conductive material. These spring strips exert tension on the nickel strips to keep them tight, and connect them electrically in series. Two leads connect to the spring strips at the ends of the nickel strips which are coated with a black heat-absorbing substance so that when IR radiations fall upon them, the temperature, and therefore the resistance, of the series combination changes.

The inward end of the bolometer housing is closed by a silver diaphragm having a central aperture. The diaphragm is soldered to the casing, and a conical window of silver chloride is fused to the diaphragm, making a gas-tight closure for the cylinder end. The window is conical to avoid reflections from the bolometer back to itself.

At its outer end, the cylinder is supported by two tubes fitted into holes. One tube terminates in a gas trap filled with carbon particles held in place by glass wool, the other in a flared portion covered by a plate through which leads are brought by means of glass beads. The container is filled with hydrogen at a pressure of about 4 mm of mercury, the trap absorbing any other extraneous gases.

The housing also contains a parabolic mirror mounted on a shaft so that its optical axis is at an angle of about 5 deg with its axis of rotation. As the mirror is rotated at 32 rps by a direct current motor, a 10 deg area revolves about the axis of rotation, thus scanning an area 20 deg in diam.

The outer end of the housing is made gas-tight by means of the large window. Like the small window, this is also made of silver chloride and is conical for strength and to eliminate reflections. To avoid condensation of moisture on the outer surface of the window, its temperature must be kept substantially equal to that of the air flowing over its outer surface. Tests indicate that a silver chloride window 0.4 mm thick will not lag more than two seconds behind equilibrium with its surroundings.



Cross-sectional view of optical system and pressure equalizing means for a heat-homing bomb.

To prevent changes in atmospheric pressure from crushing the window, a pressure equalization chamber is connected to the housing by means of hose. The open end of the chamber is covered with an airtight flexible diaphragm. Pressure in the housings is equalized by leakage through the bearing and, if necessary, through an additional opening. The diaphragm permits pressure in one housing to assume the same value as the outside pressure, without introducing moist air. To dry the air inside the optical system housing, a container filled with a desiccant may be employed.

Patent No. 2,826,703. Optical System for Heat-Homing Bomb. Alan C. Bemis, Concord, Mass.; Willard E. Buck, Inyokern, Calif.; and Ernest B. Dane Jr., Belmont, Mass., assignors to the Dept. of Defense.

Thor IRBM School Opened

A Thor IRBM training school for USAF and RAF personnel at Douglas' Tucson Municipal Airport was officially opened recently. Classes will average over 100 trainees, drawn from officer and enlisted ranks, who will learn skills needed for support of Thor subsystems and missile ground handling equipment. Douglas has received a contract for the program from the Air Training Command.

A report to engineers and scientists from Lockheed Missile Systems—where expanding missile programs insure more promising careers.

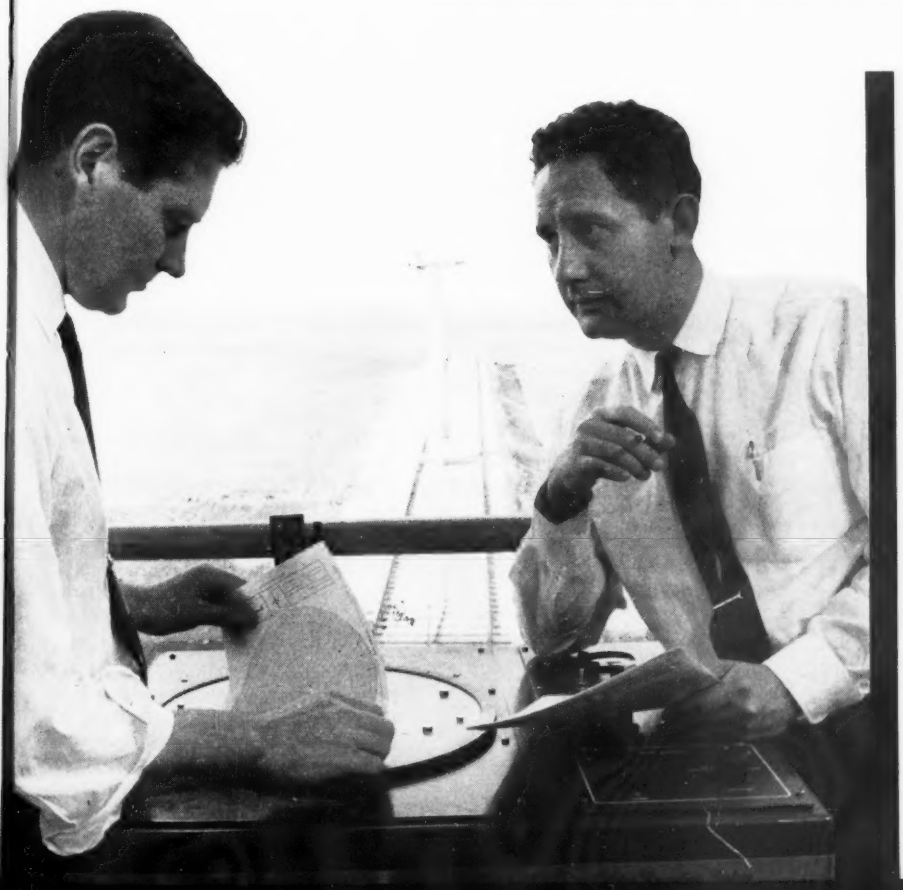
NEW LAB MEASURES ANTENNA PATTERNS; PROBES OUTER SPACE

A new laboratory at Sunnyvale, California today gives Lockheed scientists antenna patterns, scattering and propagation data, and promises exciting new discoveries in the problems of space communication. Laboratory studies include the effect of upper space on radar and radio signals, the radar pattern presented by space vehicles and missile shapes, and the design of antennas to survive the rigorous environment of the upper atmosphere and hypersonic speeds. Findings could pave the way for communication with manned space ships of the future or for the remote guidance of unmanned space ships.

Research and development studies by Division scientists contribute heavily to the projects that place Lockheed in the forefront of U.S. missile developers. These projects include the Polaris solid fuel ballistic missile, Earth Satellite, Q-5 target ramjet, and X-7 test vehicle. Positions created by expansion on these and still other programs we cannot discuss offer unusual opportunities for advancement with our growing young division. Besides Antenna and Propagation, openings are in **Solid State Electronics, Telecommunications, Instrumentation, Radar and Data Link.** Other openings include **Information Processing, Reliability-Producibility, Ground Support, Flight Controls.** Qualified engineers or scientists may write to Research and Development Staff, Palo Alto 14, California.

Lockheed / **MISSILE SYSTEMS DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, COOKE AFB, CALIF. • CAPE CANAVERAL, FLA. • ALAMOGORDO, N. M.



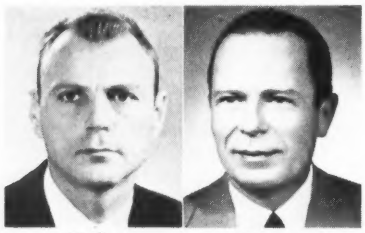
Mr. Emmanuel A. Blasi, right, Manager of Antenna and Propagation Department, discusses results of radiation performance after antenna pattern measurements with staff scientist Allen S. Dunbar. Column bearing missile in background is operated automatically from laboratory.

People in the news

George P. Sutton, ARS national president, has been appointed manager of advance design and **W. C. Cecka Jr.,** vice-president of the Los Angeles section, has been named manager of engineering test in a reorganization of the Rocketdyne Engineering Dept. Other appointments are **R. J. Thompson** to manager, research; **N. C. Reuel** to manager, large engine systems; **W. J. Brennan** to manager and **A. C. Kramer** to assistant manager, components engineering; **J. M. Cumming** to manager, small engine systems; and **J. E. Kendall** to manager, operations.

Clauser **Donovan**

Ramo-Wooldridge Space Technology Laboratories has named **Milton U. Clauser** vice-president and director of its Physical Research Laboratory; **Allen F. Donovan** vice-president and director of the Aeronautics Laboratory; and **William M. Duke** vice-president and associate director of the Systems Engineering Div.



Duke **Eppert**

Ray R. Eppert, formerly executive vice-president and director, Burroughs Corp., has been named president.

Eric Durand, special assistant to the vice-president for research and development, Aeronutronic Systems, has been selected to serve for one year with ARPA.

W. A. Pulver, assistant chief engineer, has been promoted to chief engineer, Lockheed Aircraft Georgia Div., succeeding **R. W. Middlewood,** who becomes director, Georgia Nuclear Laboratories.

William B. Bergen, executive vice-president, and **Clarence W. Miles,** general counsel, have been elected directors of The Martin Co.

Frank L. Spencer has been appointed assistant manager of engineering program development, Waste King Corp.'s Technical Products Div.

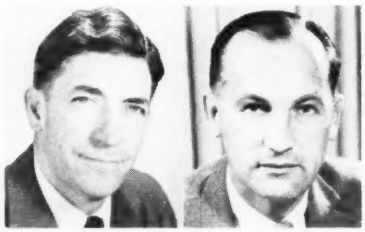
Marvin B. Ruffin, vice-president, Chicago Aerial Industries, Inc., has been named general manager and vice-president, responsible for the firm's operating activities. **Robert K. Lowry** has been appointed Western regional manager.

William C. House heads Aerojet-General's newly organized Systems Div., comprising seven departments in the fields of astronautics and applied research. Other appointments are: **M. L. Stary** and **E. R. Elko,** to chief engineer and assistant chief engineer, respectively, of the Systems Operation Dept., formerly Rockets Projects Dept.; **R. D. Waldo,** to supervisor of the newly formed Preliminary Design Dept. and **S. Eldridge,** to proposal manager of the new Special Proposal Project Group within the department.

William Kauffman of the Avionics Div. has been assigned to coordinate activities with that division and also act as guidance specialist for the Systems Div. **Tom Omori,** of the Solid Rocket Plant, will act as coordinator on all solid engine systems and provide technical assistance in preparation of proposal data; **H. B. Ellis** will head the Applied Research Dept.; and **George McRoberts** will direct a new department which will specialize in special projects in antisubmarine warfare for the Navy.

Frank G. Denison, former program director of Sergeant weapon-system development at JPL, has been named director of Interstate Electronics Corp.'s newly formed Aeronautics Dept. **Albert A. Hodgson,** formerly with the Rheem Mfg. Co. Research and Development Laboratory, joins the department as chief of analysis.

Najeeb E. Halaby, former vice-president, development, Servomechanisms, has been elected vice-president,

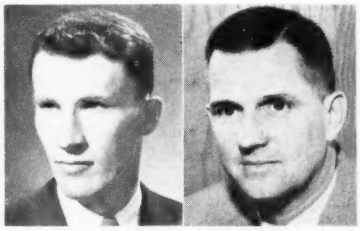


Halaby **Decker**

finance and administration, and a board member. **Gerard Q. Decker,** division manager, Subsystems Div., has been elected a vice-president.

Carleton Sprague and **Edgar Shurtleff** have joined McCormick Selph Associates as engineers in preliminary design and engineering, and in research and development of new explosive ordnance products, respectively. **Hubert Bennet,** former associate administrator, Explosives and Propellant Dept., Naval Ordnance Test Station, has been appointed assistant director, Applications Engineering Dept. and coordinator, field engineering.

Edward J. Cousin, former manager, Servomechanisms Washington office, has been named manager of the Allen B. DuMont Laboratories space and missile programs.



Cousin **Deacon**

Walter K. Deacon has been appointed chief engineer of the Vickers Aero Hydraulics Div. Torrance Plant.

Carl Smith has been named staff assistant to the vice-president, Wyandotte Chemicals Corp. Michigan Alkali Div.

Robert J. DeLargey, former assistant manager, Westvaco Chlor Alkali Div., has been named division manager and **Robert A. Bondurant** production manager.

Harry H. Wetzel, former manager, AiResearch Industrial Div., assumes the same post in the Manufacturing Div., succeeding **Claude N. Monson,** who has been appointed vice-president in charge of contract administration. **Wilton E. Parker,** former sales manager and chief engineer, Industrial Div., succeeds Wetzel as manager.

Alan M. Glover, general manager, RCA Semiconductor and Materials Div., has been appointed vice-president of the division.

Robert E. Kemelhor has been appointed manager, future product planning and development, Pesco Products and Wooster Divs., Borg-Warner Corp.

Orman

Begovich

Col. Leonard M. Orman, Chief of the Army Field Office, Air Force Missile Test Center, Patrick AFB, Fla., and vice-president, ARS Florida section, has been reassigned to duty in Korea. **Col. James D. Sams** succeeds Col. Orman.

Nicholas A. Begovich, former director, ground systems radar laboratories, Hughes Aircraft, has been appointed director of engineering, Ground Systems Group. Under Dr. Begovich, **William T. Clary Jr.** has been named to head the Systems Analysis Dept.; **John W. Bozeman** the Data Processing Laboratory; **Robert Polkinghorn** the Radar Laboratory; and **Samuel Langberg** the Engineering Services Dept.

Angelo Miele, associate professor of Aeronautical Engineering at Purdue University, has been appointed professor.

Col. Benjamin S. Mesick (U.S.A.-Ret.), former consultant and Los Angeles regional manager, Arthur D. Little, Inc., has joined Grand Central Rocket Co. as assistant to the president.

Stanley C. Pace, assistant manager of Thompson Products newly formed Tapco Group, has been elected a vice-president.

Reaction Motors Div. of Thiokol Chemical Corp. has appointed **R. W. Young** general manager and **H. H. Michaels Jr.** assistant general manager and assistant secretary of Thiokol. **J. W. Antonides** has been appointed director of the X-15 program and assistant to the general manager. New department directors at the Division are **D. C. Eaton,** marketing; **D. F. Floris,** engineering; **F. D. Pfopenhauser,** production; **E. H. Seymour,** research, and **R. M. Lawrence,** divisional controller. Other appointments are **S. M. Martin Jr.,** vice-president of Thiokol Chemical, to general manager of the newly formed Chemical Div., and **D. E. Fish,** former assistant sales manager, industrial sales, to sales manager. **F. W. Wilson,** former manager of Thiokol's Moss Point Plant, is now production manager of the Chemical Div. plants at Trenton and Moss Point, Mass.

John T. Bailey has been named chief design engineer, Vitro Engineering Co.

James E. Drummond has joined Boeing scientific research laboratories to direct research in plasma physics. **Jesse H. Zabriskie,** former director, customer relations, Special Weapons Div., Bell Aircraft, has been appointed assistant manager, Systems Test Dept., Boeing Pilotless Aircraft Div.

John F. Harrigan has rejoined Grand Rapids Div. of Lear, Inc., as manager, Dayton, Ohio Area Office. **Charles F. Pitts** has been appointed assistant general manager, Lear Astronics Div. **F. Dunstan Graham** has been named Eastern Operations Manager, Grand Rapids, Mich., and **Donald W. Dressel,** manager, Astronics Mfg. Div.

James E. Knott, former assistant manager, sales and contracts, Allison Div. of General Motors, has been named to the new post of assistant director of engineering. **Charles J. McDowall,** former chief engineer, advanced design and development, becomes technical assistant to the director of engineering. **Tibor F. Nagey** will head the expanded Research Dept. as director of research; **Russell S. Hall** and **Harvey E. Welch** will be chief and assistant chief, respectively, of the department's Preliminary Design Group. **Robert E. Henderson** will head the Applied Physics group.

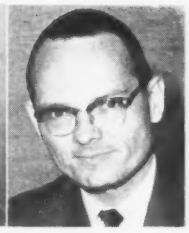
John R. Gretzinger has been appointed acting head of the new Allison Missiles Systems Dept. **Jack C. Fetters** and **Chester E. Hockert** become chief engineer and assistant chief engineer, respectively, of Turbine Engines group. Other assignments in the group are: **Gordon E. Holbrook,** to chief product engineer; **John B. Wheatley,** chief design engineer; and **Jacob C. Schmid,** chief design engineer, fuels and control systems. **Clair A. Short** and **John M. Wetzler** are assistant chief product engineers for turbojet engines and propjet engines, respectively.

William T. Smither has been appointed manager of the newly formed Special Products Div. of Servomechanisms, Inc., and **David W. Moore** has been named director of applied research of the company. Smither was head of the former Magnetics Div., while Moore was manager of the former Vacuum Film Products Div.

M. Lee Rice has been elected a vice-president of Atlantic Research Corp. Formerly, he was president of AR's subsidiary, U.S. Flare Corp.

Richard S. Morse, president, National Research Corp., has been appointed chairman of the Army Scientific Advisory Panel.

Morse



Raney

Edwin A. Raney, former senior research engineer, reliability group, North American Aviation, has been appointed manager of Wyle Research Corp.'s Dynamics Div.

E. A. Reynolds, former manager, long range planning, Convair-Astronautics, has been appointed manager of the new department of product support. **W. L. Van Horn,** former program control administrator, succeeds Reynolds and **W. W. Pierce,** Convair operations superintendent at AFMTC, Fla., will be his assistant.

Ross H. Begg Jr., former executive engineer, Pratt & Whitney, has been promoted to assistant to the general manager.

HONORS

Wernher von Braun, director of technical development, ABMA, Redstone Arsenal, Ala., and ARS board member, has been named as one of six "great living Americans" by the U. S. Chamber of Commerce, for his contributions in advancing the age of rockets.

Allen F. Donovan, vice-president, Ramo-Wooldridge Space Technology Laboratories, has been cited for outstanding service to the Air Force, and presented with an AF scroll and letter of thanks for his contributions to the Aircraft Panel of the AF Scientific Advisory Board from 1949 to 1957.

Ralph C. Lenz Jr., chief, WADC Plans Div., and **Arthur V. Sommer,** manager, American Bosch Arma's Chicago Div., have been awarded Sloan Fellowships at MIT for 1958–1959, for "demonstrating executive ability and marked promise for growth."

Karl Klager, manager, Aerojet-General's Solid Propellant Development Div., has been awarded the Navy's Distinguished Public Service Award for his contributions to Polaris propellant grain and polyurethane propellant for the Polaris program.

Marquardt Aircraft Co.'s new ramjet manufacturing plant at Ogden, Utah, has been selected for one of the "10 top plants" awards made annually by *Factory Management and Maintenance Magazine.*

Report from the Explorers

(CONTINUED FROM PAGE 40)

associates surmise that the radiation encountered is related to the so-called "soft radiation" detected by rockets in the auroral zone—that is, particles of less than several Bev energy—and that it must be associated with plasmas that markedly perturb the earth's magnetic field at an altitude of about 4000 miles. They suggest investigating the amount of atmospheric ionization, light and radio noise that would be produced under various assumptions as to the nature of the radiation.

Orbital Data Being Analyzed

It was also reported that orbital data are now being analyzed to give information on the earth's equatorial bulge and anomalies in its gravitational field. A preliminary analysis of these data has discovered that Explorer I, which was given a spin about its long axis in launching, now appears to rotate about its small axis, and that the axis of rotation may be shifting. Explorer I orientation (angle of attack) as a function of time has thus been difficult to predict, as has drag, which depends on orientation.

Orbital data have also led to new estimates of air density. Calculations now give a density of 2 oz per cu mile (about 10^{-14}gm/cc) at an altitude of 386 km, which is about 14 times the density predicted by ARDC in pre-satellite studies (see ASTRONAUTICS, April 1958, page 72). Estimates for the life of Explorer I range from three to five years in the light of current density figures.

Dr. Edward Manring and Maurice Dubin, of AF Cambridge Research Center, reporting on 10 per cent of the microphone data and about 50 per cent of the erosion-gauge data from Explorer I, indicated seven micrometeor hits detected by microphone and, for a period of 32 days, only one possible hit detected by gauge. They believe the gauges give a reliable indication that the average influx of micrometeors of 10-micron or greater diameter in the vicinity of the earth during the 32-day period was not more than 10^{-3}/sq m/sec. The meaning of microphone response, they suggest, requires further study. Erosion, in view of these data, does not appear a serious obstacle to manned-satellite flights.

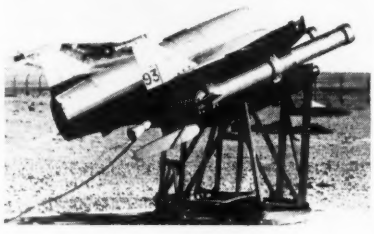
Dr. Manring and Dubin pointed out, however, that Explorer I will not be supplying data during the intense meteor showers that occur in August and November, and they emphasize that the amount of data reported can not be considered statistically significant.

Perhaps the most immediately rewarding engineering information gathered from Explorer I is confirmation that temperatures in a satellite can be controlled to within fairly narrow specified limits by simple passive means. Dr. A. R. Hibbs of JPL said that the aluminum oxide strips used on Explorer I maintained inner temperatures between 32 and 104 F—well within the tolerance of electronic equipment and man. This simple heat distributor, moreover, ameliorated any effects which changing altitude and attitude had on Explorer I. Dr. Hibbs ventured that, with somewhat more elaborate techniques, the inner temperature of a larger space vehicle could easily be controlled within a much narrower range of temperature.

This partial description of data from the Explorers, even in its tentative values, its complexities and puzzles, suggests the wealth of knowledge and practical engineering information that will be reaped by satellites.

French Rockets Undergo Testing

Above, technicians prepare to test a remote controlled Parca rocket at Colomb Bechar station, French weapons test base in the Sahara desert. Four boosters help bring the rocket to supersonic speeds while stub wings insure stability. Below, 4200 rocket is seen in profile on its launcher.



Radioactive Tracers

(CONTINUED FROM PAGE 31)

and the output can be tailored to telemetering or recording equipment. Calibration is done with a model identical to the proposed experimental setup.

The MDI system consists of a machine screw encapsulated tracer in the missile, with a receiver in the drone target to detect and measure radiation level. The system may be used in general for miss distances as large as 300 ft and at relative speeds between target and missile of not more than 3000 fps. MDI can also give detailed information on the relative trajectories of missile and target, and can actuate a flare, smoke bomb, or other signaling device when the missile passes by the target at less than a specified distance.

This system employs a scintillation detector with a completely transistorized shaping network. Its detector can be powered with batteries in a self-contained unit or can run off the target's power supply.

At a miss distance of 200 ft, the detector will show a counting rate of approximately 1000 gamma rays per second. It is interesting to note that even at high altitudes the maximum background counting rate recorded in balloon and rocket research programs has been less than approximately 200 counts per second for this type of detector.

Package Goes Anywhere

The detector package can be put anywhere in the drone, since airborne structures have a very small—though not unnoticeable—shielding influence on the passage of gamma rays. Preflight calibration will eliminate the influence of an average or nominal structure on MDI accuracy, but flight path differences can introduce small errors due to shielding. For example, the intensity of gamma radiation will be reduced 10 per cent in passing through 0.25 in. of aluminum, which we will say is the average amount of structure radiation will have to penetrate to reach the detector in the drone. The drone, however, may fly at an angle to the source of radiation that puts more than this amount of structure between them. Doubling the 0.25 in. of aluminum in this manner would, for instance, reduce the intensity of radiation at the detector another 10 per cent, and cause a concomitant 5 per cent error in measurement of miss distance in terms of preflight calibration. This variation of shielding with the approach of mis-

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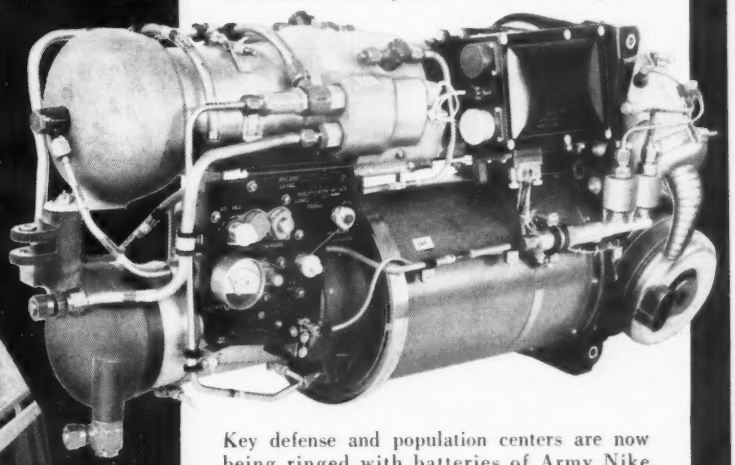

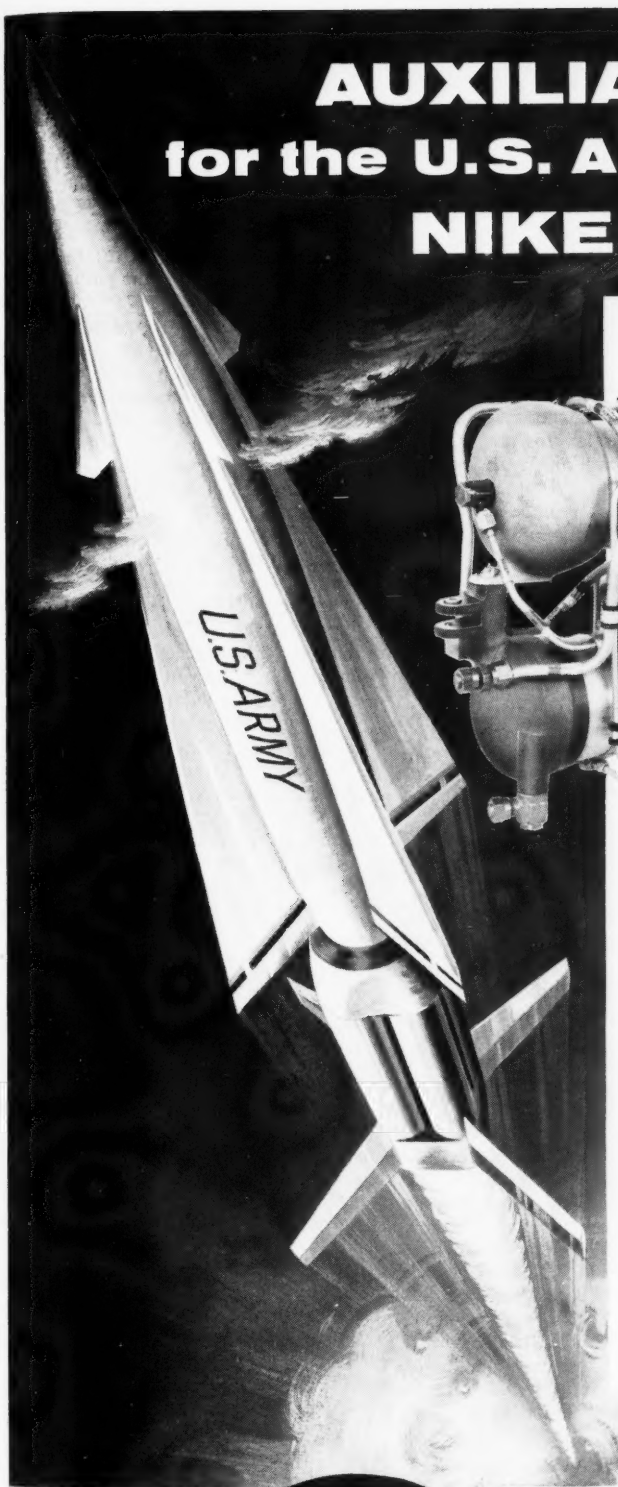

Key defense and population centers are now being ringed with batteries of Army Nike Hercules missiles to deter or destroy aggressors. *Supplying power for flight controls* is the AiResearch auxiliary power unit pictured above, now in production.

As a member of the Army-industry team producing the Nike Hercules (Army Ordnance, Western Electric-Bell Telephone Laboratories and Douglas Aircraft), AiResearch was chosen to design, develop and manufacture this vital accessory power source for the missile because of nearly two decades of experience in lightweight turbomachinery.

This experience includes applications utilizing solid propellants, liquid mono-propellants, bi-propellants, atomic power, cryogenic gases as well as gasoline and air. AiResearch's ability for high capacity production as well as in research and development, made it the logical choice.

Garrett's AiResearch divisions have also designed systems and components for 18 other missiles and rockets in the U.S. defense arsenal.

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sile to drone must be studied statistically.

Radioactive sources for MERI are of the order of 1 millicurie in intensity, and sources for MDI are approximately 1000 times larger, or on the order of 1 curie.

Procedures for handling radioactive materials in rocket instrumentation work are specified by the Atomic Energy Commission. The procedures are different for alpha, beta, and gamma radiation, and vary with the strength of the source. All personnel working with or near radioactive materials wear film badges and dosimeters for checks of radiation exposure. Lead storage containers and handling tongs of various lengths are standard equipment for working with tracers.

Based on a paper presented at the 1958 ARS Semi-Annual Meeting in Los Angeles, June 9-12, 1958.

Youthful Rocketeers

(CONTINUED FROM PAGE 39)

Cape Canaveral usually whets their appetite for conducting a few tests of their own. The result is that here, as elsewhere, kids have been fooling around with all sorts of dangerous propellants and building and trying to fire homemade rockets.

To keep these embryo engineers and scientists from blowing themselves up in their own back yards, the Florida Section Board early this year organized an Education Committee to look into the problem and see what could be done about it. Under the leadership of Captain Henry C. Paul (USA), the committee set up an educational program designed to wean local youngsters away from dangerous experiments while teaching them a little about the fundamentals of rocketry and guided missiles.

This educational program centers on the formation of science clubs at local high schools. The first such club, called the Rocket Research Society of Greater Cocoa, was organized at Cocoa High School. The organization meeting attracted an audience of some 75 or 80 youngsters, and the group is now well underway and expected to be in full stride during the coming school year.

The Committee provides lecturers for night meetings at the school at which the youngsters have an opportunity to learn a little about jet propulsion and rocket theory. Liquid propellant lectures are handled by George Woodruff of Ramo-Wooldridge; solid propellants by Phil Capdevielle of Pan American and Angelo Taiani of the Polaris Project; test activities by Les Case of RCA; aerodynamics by R. S. Ronay of Douglas and F. E. Hill of RCA; and range instrumentation and electronics by Capt. Paul.

The Melbourne High School in this area also has a Science Club with about 30 members which has expressed an interest in the educational program, and, while the Florida Section does not sponsor the club, it does furnish lecturers for the meetings. Similar groups are expected to be formed elsewhere in the area in the near future.

Through this educational program, it is hoped that high school students can acquire some fundamental knowledge about rocketry and perhaps become interested enough in the subject to seek careers in science or engineering.

As a further step in this direction, our Section is now offering nominal prizes to students who write the best papers on subjects of their own choice dealing with some aspect of rocketry or missiles. Encouraging them to do some serious thinking on these subjects can, we feel, pay big dividends in the future.

There are, of course, many other amateur rocket groups elsewhere in the state. We expect to contact these groups in the near future in an effort to find out what they are doing and what kind of assistance they require.

More Can Be Done

Obviously, our efforts in this direction to date have been tentative, and a lot more can still be done. However, we do feel that some headway has been made and that programs of this kind are a "must" to keep unsupervised and dangerous experimentation to a minimum.

While we do not feel that our program is the only way the problem can be handled, it does represent one effort to keep youngsters interested in rocketry and space flight without running the hazard of losing some of them through ill-conceived rocket firings which prove nothing even on those few occasions when they are successful.

New Wrinkle in Fueling

(CONTINUED FROM PAGE 34)

Btu/ft/hr for a $4^1/_4$-in. thickness to 79 Btu/ft/hr for a $2^1/_4$-in. thickness.

The third insulation tested was a steam-blown glass fiber material with

an 8 lb per cu ft density. Unit heat transfer was 42 Btu/ft/hr for a $1^{13}/_{16}$-in. thickness. Heat transfer decreased only slightly for thicker insulation.

A flame-blown glass fiber material of 3 lb per cu ft density showed a unit heat transfer ranging from 40 Btu/ft/hr with $2^{7}/_{16}$-in. thickness to 22.9 Btu/ft/hr with $10^{5}/_{8}$-in. thickness.

These and similar experiments have shown that an improvement over the natural snow coat of uninsulated lines is possible, yet their relative efficiency is difficult to assess.

Insulation Requires Chilldown

One of the difficulties encountered with conventional insulation is that the insulation itself requires a chilldown period, during which large amounts of the low-temperature liquid fuel may boil away. In some cases, at some stages of the chilldown process, increasing the thickness of the insulation may cause additional boiloff. Condensation and resultant freezing within the insulation itself can destroy its thermal qualities. The use of vapor seals causes further complications.

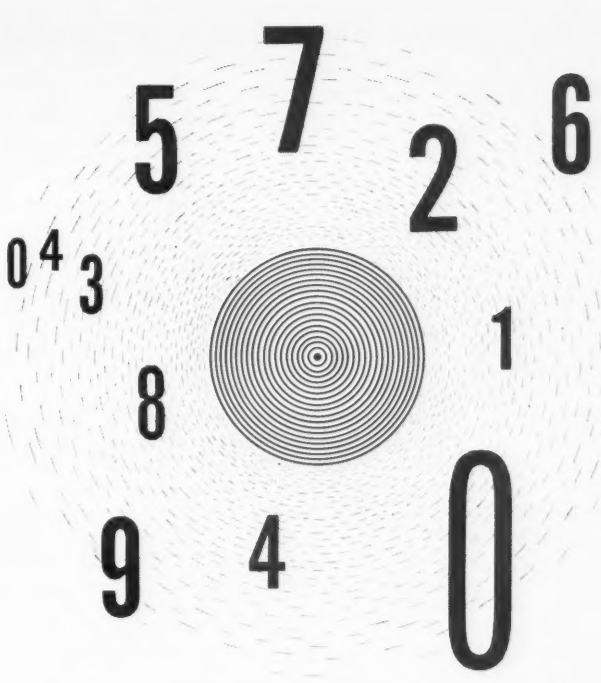
Recently, researchers have come up with an insulation that virtually eliminates boiloff losses. The material—or lack of it—is vacuum, one of the best insulators known.

The transfer lines are surrounded with high vacuum by placing one pipe inside another and evacuating the area in between. These high-vacuum-jacketed transfer lines are being produced by the Rochester Div. of Consolidated Electrodynamics Corp. Among the first installations to have the vacuum-jacketed transfer lines is the AF Missile Test Center at Cape Canaveral, Fla.

Because heat transfer as small as 5.5 to 8 Btu/ft/hr is possible, the new vacuum transfer lines can show fuel savings up to 50 per cent over conventionally insulated lines, and even more over unjacketed lines.

Each section of the fuel-bearing line is first treated on the outside to reduce radiant heat transfer and then surrounded with a vacuum jacket which is pumped to a pressure of 1×10^{-5} mm Hg or lower. This cuts both direct and convection heat transfer.

Modular vacuum-jacketed connections are also available which will permit the many configurations that may be required at the launching site. Consolidated also supplies all the high-vacuum pumping systems, gauges, jacketed valves and leak detectors necessary for proper use of the transfer lines. Jacketed lines are currently available in sections up to 40 ft in length.



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Russians Release First Data on Sputnik II Biological Experiments

Biological data obtained from Sputnik II indicate that Laika withstood the conditions of space flight well, despite the fact that the dog's heartbeat took about three times longer to return to its normal level during orbital flight than in laboratory experiments.

This was the conclusion reached by Soviet scientists who recently made public the first appraisal of results obtained in its satellite biological experiments.

They noted that, in the vehicle's ascent to orbit, the animal was placed in a position where acceleration acted on it from chest to back, pressing Laika to the floor of the chamber. This position was chosen because it was regarded as being most favorable to the animal.

Withstood Acceleration Well

Analysis of data indicates the animal withstood the high g loads of acceleration quite well. Immediately after launching, the frequency of heart contractions approximately tripled as compared with initial frequency. Electrocardiograms failed to show any morbid symptoms. Later, when acceleration not only continued, but mounted, heartbeat frequency diminished. At the same time, breathing became more difficult, rising to three or four times the normal rate.

Under weightless conditions, with the satellite in orbit, the animal's body no longer was compressed against the chamber floor and, by contracting its muscles, it easily pushed itself off the floor, using brief and rather smooth movements.

The Russians supplied a reason for the long period of time it took for the dog's heartbeat to return to its initial frequency. They noted that, in ground experiments, the animal was in normal conditions after simulated acceleration, while in the satellite it was in a condition of weightlessness. In this state, that part of its nervous system which normally would indicate its position in space was not sufficiently affected by external stimulants. This conditioned a change in the functional state of that part of the nervous system regulating blood circulation and respiration, resulting in an extension of the time for normalization of these functions after acceleration ended.

There is also a possibility that this phenomenon was intensified by the vibration and noise which accompanied acceleration, which may have been greater than that achieved in lab experiments.

The Soviet scientists noted that the change in physiological functions noted in the animal at the beginning of orbital flight coincided with the result of previous investigations carried out in high-altitude rocket experiments.

Normalization of blood circulation and respiration during weightlessness indicates it did not cause any major changes in the animal's physiological functions.

Normal atmospheric pressure, with an oxygen content of 20–40 per cent, was maintained in the chamber, the Soviet scientists said, with carbon dioxide content held to no more than 1 per cent by air regeneration. No mention was made of the type of chemicals used as regenerating substances, although they did say the compounds employed absorbed noxious gases formed in the course of the animal's vital activity.

No data were obtained relative to the impact of cosmic radiation on Laika, and no clear physiological ef-

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fects were detected directly. This would have required detailed examinations after the flight and this, of course, was impossible.

While the Soviet scientists explained that this was planned in future flights, Yevgeny Federov of the U.S.S.R. Academy of Sciences noted at a press conference in Moscow a few days after Sputnik III was launched that, while the new Soviet satellite represented a major step toward manned flight, "this is a difficult problem and will require great efforts for solution."

—I.H.

Space Age Workshop

(CONTINUED FROM PAGE 38)

of missile design and development could be covered completely, representatives of all major departments at Martin were on hand during the 10 weeks to give teachers a step-by-step picture of how the industry operates. One of the first sessions, for instance, dealt with the sales department, answering such questions as how a company like Martin obtains a contract, what qualifications sales engineers have to have, how decisions are made on what government contracts to bid on, etc.

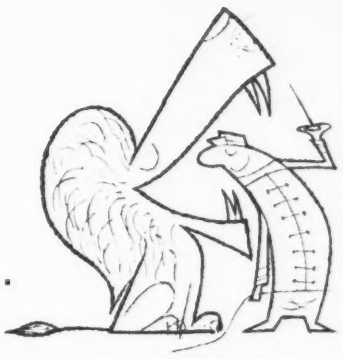
The next session was devoted to the building of an organization—how a company decides to build a plant in a certain city, how the plant is staffed, role of the personnel department, etc.

Succeeding sessions covered engineering, manufacturing, and testing, in that order—just as the actual departments would operate in development of a missile system. Later sessions covered the broader aspects of the space age—space flight, space medicine, and other subjects. These topics were introduced and discussed by Martin advanced design specialists.

The series ended with a tour of the Martin-Denver test area and a dinner at the plant cafeteria. Transcriptions of the entire series have been made and distributed to the teachers who participated.

In the course of the workshop, every effort was made to stress the integration of mathematics, the sciences, social studies, the humanities, and even fine arts in the space age. Neither Martin nor the Littleton Board of Education felt that emphasis on science and engineering preparatory courses represented the whole answer to the alleged shortage of engineers. Instead, the feeling was that *all* school courses are important, and that overemphasis of science can be as unwise as underemphasis.

The sessions were so successful that another space age workshop is planned for this Fall in another greater Denver community. The lessons learned from the Littleton course will, it is hoped, enable the company to provide local teachers with even more in the way of know-how to impart to their students about rockets, guided missiles, and the age of space.



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Vanguard Failed to Orbit, Rose 2000 Miles, Navy Says

The Navy has announced that its attempt to orbit a 20-in. Vanguard satellite on May 27 had been unsuccessful because the vehicle was hurled at an angle too sharp for orbiting, and that it had probably fallen back toward earth after traveling 2000 miles up. There was no official explanation about the angle of flight or details about the shoot except that first indications pointed to a successful launching.

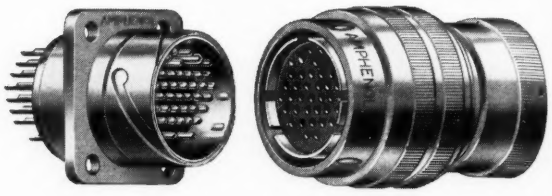
Richard W. Porter, chairman of the IGY Earth Satellite Panel said that the Antigua tracking post had heard signals from the satellite for about 20 minutes, twice as long as the Vanguard should have taken to pass out of range. This, he noted, indicated the satellite was traveling on a high upward angle, or traveling very slowly.

In spite of the failure, officials said much valuable scientific information had been gained. The mission was supposed to determine how solar ultraviolet radiation affected radio communication.

MINNI*E* CONNECTORS

AMPHENOL

pass tough, new ALTITUDE-MOISTURE RESISTANCE TEST salt water immersion, 65,000 feet altitude



Designers and manufacturers of aircraft and missiles, as well as the military, have long recognized the need for a connector altitude-moisture test which would accurately simulate actual performance conditions. Such a test has been developed by manufacturers and the military and applied as standard procedure on the 67 Series ***MINNIE*** connectors in the AMPHENOL Laboratories. It consists of the following:

A plastic tank is filled with distilled water and salt added to obtain a solution of 1.050 specific gravity. Marker dye is added for tracing leakage paths. The connectors are given a dry insulation resistance (IR) reading with a 500 volt megohm bridge. All coupling rings are then securely hand-tightened and grommet clamps rechecked for tightness. The connectors are then completely submerged in the salt solution so that all cable bundle ends are out of the solution. The ends of the cable bundle from one side of each connector are taped. The tank and connectors are placed in an altitude chamber and another IR reading is made.

The pressure inside the chamber is then reduced to 0.82 inch of mercury (80,000 feet altitude) and held for one minute, then increased to approximately 2 inches of mercury (65,000 feet altitude). After maintaining 2 inches of mercury for ½ hour, the chamber is returned to room ambient pressure for ½ hour. This is considered one complete cycle. Connectors are subjected to a total of 10 cycles.

At the conclusion of the tenth cycle, connectors remain completely submerged in the salt solution container at room-temperature and pressure for an over-week-end soak (65 hours). Final insulation resistance reading is then taken. Immediately after last IR measurement, specific gravity of salt solution is taken.

The "E"-type construction of AMPHENOL 67 Series ***MINNIE*** connectors was originally designed to meet the moisture resistance requirements of MIL-C-5015C, Paragraph 4.5.21. Since the development of the new and far more stringent altitude-moisture test, ***MINNIE'S*** construction design has been modified and all AMPHENOL ***MINNIE*** "E"-type connectors pass this test.

Following the altitude-moisture resistance test, insulation resistance measurements (in megohms) on production ***MINNIE*** "E" connectors were as follows:

Cycle	Insulation Resistance	
	Contact to Contact	Contact to Shell
0 (Initial)	6000	7000
1	7500	4000
2	5500	3200
3	5500	3000
4 (overnight 17 hour soak)	3000	1100
5	2800	1100
6	3000	1100
7	3000	1100
8	3000	1100
9	3000	1050
10	3000	1050
11 (overnight 17 hour soak)	2800	1000
12 (weekend 65 hour soak)	3000	1050

AMPHENOL ***MINNIE*** "E" connectors not only meet but surpass the requirements of this tough new test. 100 megohms is the minimum insulation resistance required by MIL-C-5015C after moisture; ***MINNIE'S*** minimum insulation resistance after immersion and altitude cycling is 1000 megohms.

67 Series ***MINNIE*** "E" Connectors

DESCRIPTION Miniature, multi-contact electrical connectors of the quick-disconnect bayonet lock type. Available as Plugs, Cable and Panel Receptacles, and Single Hole Mounting Receptacles. Shell design classes include:

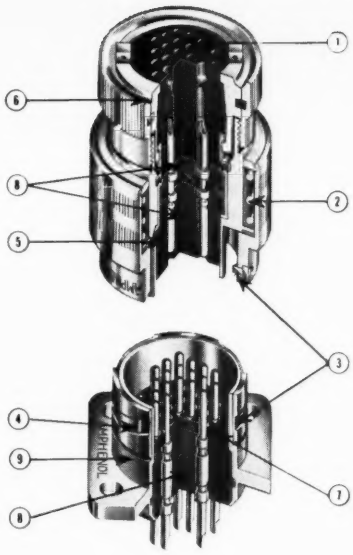
CLASS E—Environmentally resistant—individual wire seal
CLASS P—For potting
CLASS H—Hermetically sealed
CLASS J—For jacketed cable
CLASS C—Standard cable clamp

There are five shell sizes, and 17 insert arrangements—ranging from 3 contacts in the smallest to 48 contacts in the largest.

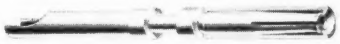
PART NUMBERING Descriptive part numbering of ***MINNIE*** connectors follows that used with AN (MS) connectors.

NOMINAL CURRENT RATING #20 contact is rated at 7.5 amperes and #16 contact at 17.0 amperes.

OPERATING TEMPERATURE −67°F. (−55°C.) to +257°F. (+125°C.).



HOODED SOCKET CONTACTS



Both #16 and #20 socket (female) contacts of AMPHENOL *MINNIE* connectors are resistant to test prod damage. The entering end of the socket has a one-piece hood that excludes the entrance of a pin 0.005" larger than the diameter of the mating pin. AMPHENOL Specification 340-43-2108, paragraph 4.5.14, gives this test to be used to determine resistance to test prod damage:

> *"A test prod of hardened steel having a diameter equal to a nominal mating pin shall be inserted into each socket contact to (a) .200 inch; (b) .255 inch; and (c) .310 inch depth. At each of these depths, measured from the face of the insert, a bending moment of 2 inch lbs. ±10 percent shall be applied to the 16 size contact prod and a bending moment of 0.8 inch lbs. ±10 percent shall be applied to the 20 size contact prod about the inserted ends of the prod. The connector shall be rotated in one direction through 360 degrees in order that a uniform force is applied to the inside surface of the socket contact. This test shall be performed with the socket contacts in the inserts and the contacts locked, if necessary, to prevent rotation in the inserts during the test."*

After withdrawal of the fixture at the completion of the above precedure, the force needed to engage or separate the socket contact shall not exceed the following values:

Contact	Max. Force Ounces	Min. Force Ounces
#20	12	2
#16	26	3

FEATURES OF AMPHENOL *MINNIE* CONNECTORS

(1) Environmentally sealed with unitized back end grommet. (Also available with provision for potting.) Grommet seal (type "E") meets altitude-moisture resistance requirements. Either grommet seal or potted seal meets moisture resistance requirements of MIL-C-5015C, Paragraph 4.5.21.

(2) Spring-loaded coupling ring provides a positive locking action in the bayonet slot, and a constant compensating force which eliminates the effects of resilient face seal compression set.

(3) Stainless steel bayonet slots and pins reduce wear and frictional characteristics and eliminate wear encountered with "hard-coat" and similar surface treatments of softer base metals. The three pin bayonet coupling minimizes the rocking action of the mated plug and receptacle.

(4) Flattened incline angle of bayonet slots reduces mating force requirement.

(5) Hooded contacts resist test prod damage as defined in Paragraph 4.5.14 of AMPHENOL Specification 340-43-2108.

(6) Unitized grommet seal; clamp and grommet form a single unit for ease of assembly and maintenance.

(7) Face seal gasket with individual barriers to isolate each contact.

(8) Hard insert dielectric (plus resilient face seal) positively retains contacts with no possibility of contacts being pushed out of the insert.

(9) A visual full engagement indicator is included in the design to insure the user that he has fully engaged the connectors. The indicator is an orange line around the receptacle shell.

- Insulation resistance of "E" type following altitude-moisture resistance test is a minimum 1000 megohms. MIL-C-5015C minimum following type "E" test is 100 megohms.
- When using mated sealed connectors, no derating for altitude is necessary at 70,000 feet.
- Test voltage 1,500 volts RMS 70,000 feet on sealed connectors.
- Vibration per Method 204 of MIL-Std-202A. 10 to 2,000 cps at 20 g's.
- Temperature cycling range per MIL-C-5015C, Paragraph 4.5.3 increased to 257°F. maximum and −67°F. minimum.

VOLTAGE RATING

	Rating	Mechanical Spacing (Nominal)	Flashover V-Rms	Test V-Rms	Recommended Working Voltage DC	Recommended Working Voltage AC
Sea level (unsealed)	A	.034	2,000	1,500	700	500
	B	.046	2,300	1,800	840	600
Sea level (sealed)	A	.034	2,500	2,000	700	500
	B	.046	3,000	2,500	840	600
70,000 ft. (unsealed)	A	.034	500	375	175	125
	B	.046	600	450	210	250
70,000 ft. (sealed)	A	.034	2,500	1,500	700	500
	B	.046	3,000	1,800	840	600

Send for your copy of the MINNIE catalog to obtain complete information.

AMPHENOL ELECTRONICS CORPORATION
1830 S. 54th Ave., Chicago 50, Illinois

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From the earliest Assyrian "artillery missile"—with the flint-tipped warhead and hawk feathers for a guidance system—the fate of nations has been in the hands of the missile men.

Today, our strength in military missilery may hold the key to survival.

Martin based its long-range planning on that probability in 1946 with the development of one of this nation's first successfully operational guided missiles. The result is the *total missile* concept.

Under this concept, far more is involved in missile system contracting than the design and production of hardware:

The testing, packaging, delivery, maintenance, launching, operation, field training and contractor service requirements make up the *total* story of missile performance...in the air, and operated by the military personnel.

The heavy demands of our country's greatly accelerated missile and space development programs now emphasize the importance of Martin's total capabilities as a major resource for the military and astroscientific branches of the government.

Among those capabilities are three plant facilities which include the newest and most advanced missile development centers in the world.

Also part of these Martin capabilities is one of the great U. S. resources in manpower: More than 3,000 specialist engineers, trained and teamed in the *total missile* concept.

This is one of the few systematically organized companies of genuine Missile Men in the country.

MARTIN

BALTIMORE·DENVER·ORLANDO

Off-Site Test Center

(CONTINUED FROM PAGE 27)

ways of dealing with manpower.

First, the schedule can be revised, but this is an unpopular solution, to be avoided if possible. Another approach would be to work the first-shift crews overtime in affected areas. Depending on the size of the problem and how frequently it occurs, this may be an acceptable solution, but one with disadvantages: Crews get tired and, over long periods, it's doubtful that a great deal can be gained. Overtime, moreover, tends to become habit-forming and may get out of hand.

A small team of men from the home plant offers a third way of handling work-load problems at the test base. Having mocked-up a configuration change and worked with the engineers during its conception, a group like this would obviously be able to do a good job of making the change at the test site. Unfortunately, while they are at the base, the task they would normally be doing at the home plant suffers; and, since they are unfamiliar with the operation at the base, careful planning is required to prevent undue interference with the normal shop support operation.

A partial second shift may be the solution after the trend of problems becomes clear. A partial second shift reduces overtime, cuts travel time to a minimum, and allows a cushion of trained technicians and mechanics to be built up to absorb the shock of schedule slippage, late parts delivery, and configuration changes at the test site.

Centers on Engineering Section

The test base organization centers about the engineering section. This group can get large if the assumptions used in discussing the shop support group hold. Test procedures written by engineers at the home plant may of necessity be changed by engineers in the field because of late changes in missile or ground equipment; parts shortages may eventually be covered in the field by substitution; a certain amount of engineering must be given to the shop to accomplish the task; last-minute changes in missile instrumentation mean the possibility of both design and procurement changes at the test site, etc.

Here, again, a steady stream of engineers from the groups affected in the home plant may cover the needs of the test site. However, each man is a stranger to the test organization; and he has no basic desire to become a part of, or adhere to, organizational policies of the test site. His only pur-

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pose is to accomplish his particular mission as quickly as possible and leave.

To maintain well-controlled test activities under such conditions, test site engineers must be respected in their particular engineering fields by the engineers responsible in this area in the home plant. The best way to keep confusion and travel to a minimum is to have adequate communication lines set up between responsible engineers. Average day-to-day problems can thus be resolved quickly and effectively.

Data taken during a test run must be looked at by the test site engineers for two main reasons: Certain parameters must be analyzed to make sure that tests will be safe to run, and the data must be examined sufficiently to assure field test engineers that instrumentation providing fundamental data operated satisfactorily. It is difficult to specify the amount of analysis the engineers at the test site should do. A normal tendency for a test site is to go overboard in this area, again increasing the manpower requirement. Data is the most important product of the test site, and its people naturally take pride and care in preparing and presenting it.

Another factor affecting manpower is the importance of a few hours at this point in the schedule in looking at specific data, particularly if a failure has occurred in the test. For a man at the test base, it seems as if schedules get more important and time gets shorter as milestones are passed. He may well see more help as the solution to this problem.

In a test organization comprised of several test sites, it is normal to have the detailed breakdown of the raw data take place in a reporting and analysis group at the home plant. When it becomes necessary to do a more than normal amount of data analysis at a site to expedite reporting, help should be borrowed from this reporting and analysis group.

Affect Size of Other Groups

Policies generated to solve these problems of the engineering and shop-support groups also affect the size of other groups at the test base, such as those for materials control. In an R&D program, it is unlikely that parts contractors and vendors can keep the pipelines full of approved packages; and, to expedite the program, it may become necessary to change parts within a package at the test site. These changes can lead to a need for more technicians, laboratories, inspectors, material control, accountability personnel, and stock room space.

The materials control group is also affected by a second shift. Dispatching service, tool cribs, and stockrooms must be kept available and operating.

Now let's look a moment at range time. Range time is a problem because the number of bases with range facilities adequate to handle IRBM and ICBM missile programs is limited, while the number of these programs has increased considerably in recent years. Available range time directly affects the type of flight test program planned. For example, a program of four missile operations a month, including the necessary tests leading up to the actual launching, may need to be revised if the range will only allow two launches per month. The availability of other facilities, such as those for storing propellants, may affect the number and type of tests, other than flight tests, that can be performed at the base, and thus in turn affect the size and type of organization necessary.

We can also draw some conclusions about the larger organization of the test base. The field test base is in effect a small division, each department of the home plant being represented. The base may have several hundred people. Hiring, training, transporting, and housing these people is worth a great deal of prompt attention early in planning.

As soon as facilities and services furnished by the base at which the test site is to be established are known, test site organization should be decided on and hiring of people for key positions expedited. Hiring of key people should start a year before field testing actually begins—a minimum time for security clearances to be processed and training at the home plant. During this year, engineering, shop support, and materials people must become acquainted with the missile they will operate and launch. A dispatcher who knows the stock number, identity, and whereabouts of each part can be extremely important when the test program has started.

All key people involved in the field test group should be given the opportunity to work for a time in the home department corresponding to their section of the field test organization, so as to learn the policies and responsibilities of the department. The opportunity to know and work with the individual members of the same group will also be of great advantage when they are operating at the test base. The training that the key personnel get prior to start of operations at the test site must continue at the test site, and be extended to include all personnel in the various groups who have the need to know.

Groups in the test base organization will not be busy at all times as

during a countdown, which may last four to eight hours, many men cannot work on their normal assignment, and certain areas of the test site must be cleared of workers. Men who would normally be working on the missile or test equipment may be idle. Careful planning can put these and other idle periods to good use with well-planned training programs.

It is not hard to conclude that the off-site test base must be flexible in both organization and people. As program demands will vary, and as the base assistance may vary, the test organization must contract here and expand there to cover the necessary tasks.

Based on a paper presented at the 1958 ARS Semi-Annual Meeting in Los Angeles, June 9-12, 1958.

First Space Ship

(CONTINUED FROM PAGE 37)

aircraft.

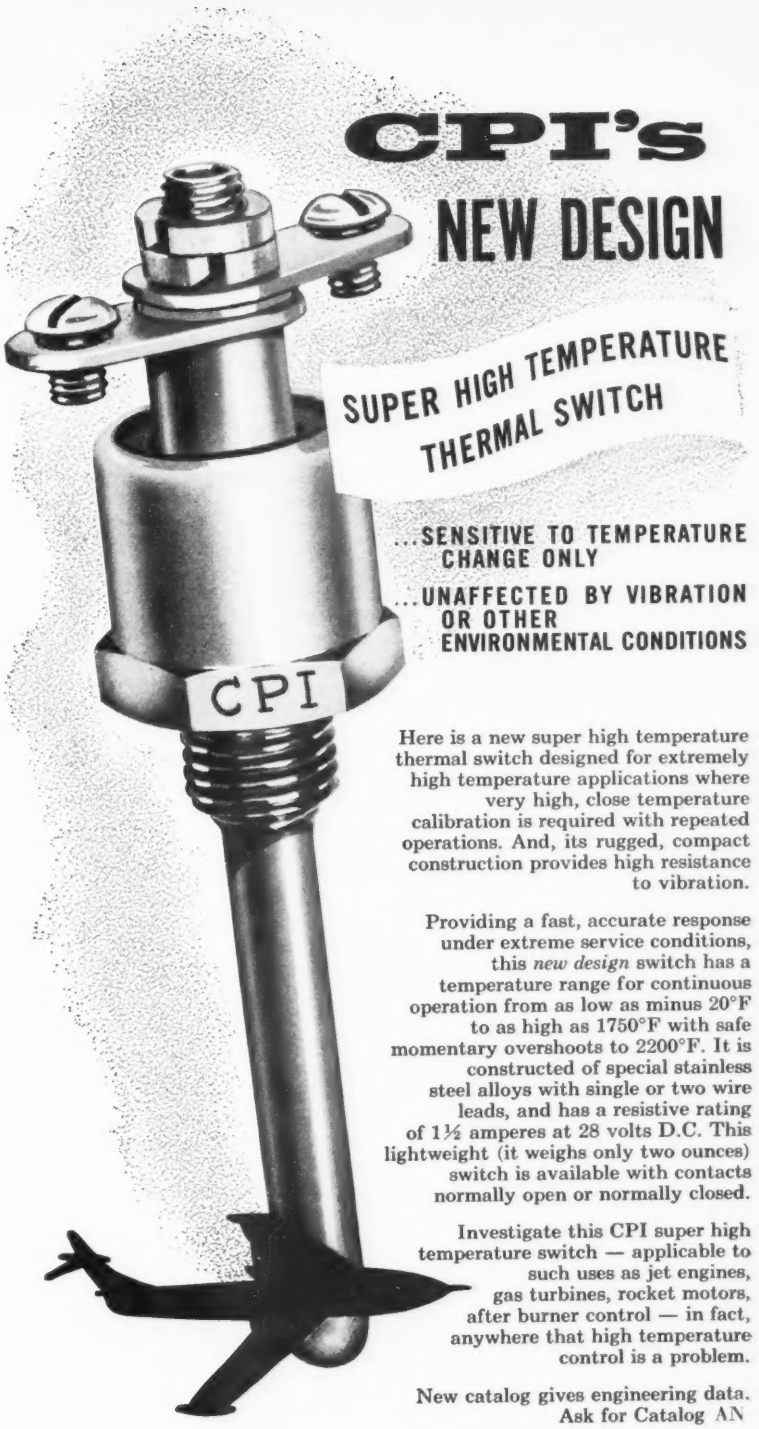
North American engineers are attacking the problem with every weapon at their disposal, including attempts to attain as good a laminar flow boundary layer as possible. Before the X-2 went aloft, engineers spread a silicone aerodynamic filler over the wings, let it harden, and then sanded it down and checked it with templates to assure smoothness. After this process, the wings were rubbed briskly with chamois to make them super-smooth. All this in an attempt to maintain laminar air flow.

But even the smoothest wing surfaces and the best boundary layer can be broken up by shock waves or other forces. If this occurs, the boundary layer becomes spotty, the air becomes turbulent and friction may easily increase to a point where aerodynamic heating turns the metal cherry red.

With the X-15, two major problems are thermal creep and thermal cracking. In re-entry, the metal may become so hot that it will weaken and literally "creep." As the heat increases and the metal softens, hypersonic blasts of air may hammer it out of shape in a creep, or flow—not enough to be visible to the naked eye, perhaps, but enough to disrupt the laminar boundary layer.

This starts a vicious cycle, since a turbulent layer will heat the ship six times as fast as laminar airflow. Keep this up for only a short period of time and you need a new aircraft.

The cracking comes about this way. Aerodynamic heating in re-entry will mean extremely high temperatures at metal wing and fuselage surfaces. Within the wings and fuselage, however, heavy metal spars will remain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relatively cool. On the surface, then, the metal expands; within the wings, it does not. If this temperature difference becomes too great, something has to give, and "cracking" may result. Sometimes this failure is manifested in the form of wing warp, causing a destructive change in control effect or even structural failure. In either case, the result is likely to be fatal.

To combat these dangers, the X-15 will be all "hard metal," primarily new nickel and steel alloys. It will have an external armor of nickel alloy. Heat that manages to get through this resistant skin will next encounter a layer of titanium and stainless steel alloy. This construction is designed to take temperatures up to 1000 F.

To save weight, chemical milling has been used extensively in manufacturing the ship's side panels. The X-15 is about 65 per cent welded and 35 per cent fastened, with both automatic fusion and resistance welding techniques used. Hydraulic tubes are brazed together to eliminate threaded fasteners on tube ends and prevent leaks. Missile type high-pressure tanks are used for the fuel system.

North American now estimates that temperatures on the leading edges of the wings and on the nose of the ship will reach "several thousand degrees." The magnitude of the problem can be judged by the fact that the X-15's heating rate will be 70 times faster than that of the Mach 2 F-107.

For its flights, the X-15 will be carried to about 40,000 ft by a B-52 and dropped at an approximate speed of 400 mph. From this point, the pilot will climb toward the sky, with the ability to throttle the rocket engine in a conventional fashion.

Special Instrument System

No other aircraft has ever had so many pilot assists designed merely to tell him where he is. Since near vacuum operation negates usefulness of such instruments as the airspeed indicator and altimeter, the X-15's pilot will rely on a primary inertial navigation system to tell him his exact position in space.

A special flight instrument system developed for the X-15 by Sperry Gyroscope will enable its pilot to control the ship from re-entering dense atmosphere too steeply and burning up, or bouncing back too high from too shallow a trajectory. The new system can withstand accelerations in excess of 10 g's. Automatic inertial flight aids and sensing devices will display precise position and navigating data visually and each flight will be electronically charted by airborne recorders. In effect, Sperry notes, the pilot "is designed into this short-time-of-flight inertial system as a super-intelligent servo link."

Since any disturbance under the high inertia conditions of hypersonic flight could easily throw the ship "out of balance," every attempt has been made to simplify pilot control of the vehicle. For example, in addition to his regular stick controls, the pilot will be provided with a set of flight controls built into the right side of his seat which can be operated solely through movements of his right wrist.

One final problem still remains: How to get the pilot out of the ship if everything goes haywire. Obviously, ejection at the top speed and altitude the X-15 will reach is out of the question. The solution is simple. A calculated risk is taken that there will be little or no danger of fire or explosion, and that the tenuous atmosphere at maximum flight velocities reduces to a minimum the danger of structural failure. Thus no provision is made for pilot escape under these conditions.

Instead, if the pilot finds he must abandon the X-15, he will remain with the machine until his speed is low enough to permit ejection. Protected by a special pressure and thermal suit, and ejecting in the latest type "stability" seat, he has an excellent chance of survival—great enough, Crossfield believes, to be better than that provided by any other research aircraft.

Despite all the publicity the X-15 has received, its origins have largely gone unnoticed. The organization primarily responsible for the X-15's existence is NACA. Referring to flights in the older rocket planes, Crossfield, a former NACA test pilot, says: "It was pretty obvious we were handicapped by the planes in the NACA stable. Higher speeds and greater altitudes were needed. We had to have something beyond the X-2, and nothing was in sight. We needed something new, revolutionary. . . . We talked it over among ourselves at NACA, and the idea was also considered by other research groups. The Air Force and Navy were with us all the way. The big opening we saw was the tremendous power advances in available rocket engines."

In July, 1954, NACA met with the Air Force and Navy, and convinced the two services that the X-15 should be built as an extension of the cooperative research aircraft program. NACA became technical director of the project, and late in 1955 North American won an AF award for three aircraft, with Reaction Motors receiving a contract to develop the 60,000-lb thrust engine required. The Navy has provided major assistance in financing and test facilities, notably its centrifuge

at the Johnsville, Pa., Naval Air Development and Materiels Center.

"Basically," Crossfield notes, "the research vehicle was to represent the maximum in altitude and speed we could attain with a single-stage rocket, using existing fabrication techniques and materials, in the shortest time possible. We established the need to investigate and report on three things: Stability and handling of such a ship at extreme speeds and altitudes; handling qualities in extra-atmospheric flight; and the effects of aerodynamic heating on an airframe."

After the X-15 has been put through its paces and its "integrity" has been established, the Air Force will turn it over to Capt. Kincheloe. The ship's normal flights will be hairy enough, but present plans call for mating the X-15 with an SM-64A Navaho booster. That means a kick of some 400,000 lb of thrust just to get the ship upstairs, after which its own engine will take over.

Estimated performance with the Navaho booster? About 300 or 400 miles of altitude and as much as 5 mps velocity.

In other words—a manned orbital vehicle.

World Scientists to Attend AF Space Meeting Nov. 10-12

An impressive program is taking shape for the AF School of Aviation Medicine Space Symposium to be held Nov. 10–12 in San Antonio's (Tex.) Hilton Hotel. Here, for the first time, IGY data on the cosmos will be made public. Co-chairmen of the symposium are Maj. Gen. Otis O. Benson, Jr., commander of the school, and Hubertus Strughold, founder of space medicine.

Acceptances have been received from the following top U.S. satellite and rocket research experts, with the names of foreign scientists expected to attend to be released later: Hugh L. Dryden, NACA director; Joseph Kaplan, IGY National Committee director; Fred L. Whipple, director, Smithsonian Astrophysical Observatory; James A. Van Allen, University of Iowa; Gerard P. Kuiper, University of Chicago; S. Fred Singer, University of Maryland; and Ernst Stuhlinger, ABMA. The various papers to be read will be published later under one volume as a fundamental work on space research.

New Funds for JPL

The California Institute of Technology has been awarded a $22,771,492 Army Ordnance contract for operation of the Jet Propulsion Laboratory during 1958. A supplemental award of $10 million is expected shortly.

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Government contract awards

Solid Propellant Study

A contract for research on the behavior of solid propellants in rocket engines has been let to Aeronutronic Systems, Inc, subsidiary of Ford Motor Co. The study will explore the influence of sound waves on chemical reaction rates, a significant factor in combustion instability.

High-Energy Fuel Contract

The Navy Bureau of Aeronautics has awarded a $31,367,663 contract to Callery Chemical for startup of the Navy-Callery plant at Muskogee, Okla., which will produce HiCal, high energy fuel for jet aircraft and missiles.

Guided Missile Study

Aeronutronic Systems, Inc., has been awarded a $482,050 contract by the Army Signal Corps for a 15-month study in the guided missile and range instrumentation field for the Signal Supply Agency Laboratory Procurement Support Office, Ft. Monmouth, N.J.

Tartar, Terrier Computers

Navy BuOrd has awarded Ford Instrument Co. a $14 million production contract for computers for the Tartar and Terrier surface-to-air missiles.

Hawk Powerplant Contract

Aerojet-General has received a $1,650,000 Army contract for production of powerplants for the Hawk antiaircraft missile.

Nike-Hercules Launchers

Ground handling and launching equipment for the atomic-capable Nike-Hercules guided missile are being produced in quantity for Douglas Aircraft by subcontractor Consolidated Western Steel Div. of U.S. Steel.

FMC to Build Bomarc Launchers

Food Machinery & Chemical Corp. has received a production contract for an undisclosed amount from Boeing to build launcher-erectors and power-pack units for the Bomarc missile.

Hercules Powder Gets Contract

The Army has awarded a $15 million contract to Hercules Powder Co. for production of rocket and guided missile propellants and propulsion systems.

Lacrosse Nose Cones

Solar Aircraft Co. has received a contract for nose cones and fuselage support sections for the Army's Lacrosse guided missile.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

ARMY

Cleveland Ordnance Dist., 1367 E. 6 St., Cleveland 14, Ohio.

Fixed price contract with price redetermination for Nike-Hercules, Jato XM 30 solid sustainer motor, $1,236,887, **Goodyear Aircraft Corp.,** 1210 Massillon Rd., Akron, Ohio.

Corps of Engineers, Office of the District Engineer, U.S. Army, Engineer Dist., Tullahoma, Tenn.

Construction of nitrogen distribution system, Part III, and carbon dioxide system for supersonic circuit of propulsion wind tunnel, Arnold Engineering Development Center, Tullahoma, Tenn., $189,600, **Gowdy & Dukin, Inc.,** 671 Tenth St., N.W., Atlanta, Ga.

New York Ordnance Dist., 180 Varick St., N.Y. 14, N.Y.

Design and development of inertial devices, $398,802, **Ford Instrument Co.,** 31-10 Thomson Ave., Long Island City 1, N.Y.

Design, develop, and fabricate circumferential welding fixture for Jupiter missile center sections, $71,857, **Air Reduction Sales Co.,** 150 E. 42 St., N.Y. 17, N.Y.

Study, design, and fabrication of prototype accelerometer monitors for the ground equipment in Jupiter guidance system, $91,073, **Bulova Research & Development Laboratories,** 62-10 Woodside Ave., Woodside 77, N.Y.

Philadelphia Ordnance Dist., 128 N. Broad St., Philadelphia, Pa.

Engineering, design, assembly, test, and checkout of VFH transistorized components to be used in telemetering and tracking of satellites, $93,647, **Philco Corp.,** Government and Industrial Div., 4700 Wissahickon Ave., Phila. 44, Pa.

Motion study of spin-stabilized rockets during burning, determination of experimental data, and simplified analysis of data, $66,100, **N.C. State College of Agriculture & Engineering, Univ. of N.C.,** Raleigh, N.C.

Nike spare parts and components, $5,309,679, **Western Electric Co.,** 120 Broadway, N.Y. 5, N.Y.

Engineering study on improvement of manufacturing techniques for guided missile wiring harnesses, $99,922, **Hoover Electronics Co.,** 110 W. Timonium Rd., Timonium, Md.

Pittsburgh Ordnance Dist., 200 Fourth Ave., Pittsburgh 22, Pa.

Research and development study on explosive hazards of liquid propellants, $29,885, **Combustion & Explosives Research, Inc.,** Alcoa Bldg., Pittsburgh 19, Pa.

San Francisco Ordnance Dist., 1515 Clay St., P.O. Box 1829, Oakland 12, Calif.

Standard analytic methods for cost, schedule, budget control over missile system programs, basic research contract, $54,525, **Stanford Research Institute,** Menlo Park, Calif.

Springfield Ordnance Dist., Springfield 1, Mass.

Telemetering station, $92,533, Data **Control Systems, Inc.,** Danbury, Conn.

U.S. Army Electronic Proving Ground Procurement Office, U.S. Army Signal Supply Agency, P.O. Box 748, Ft. Huachuca, Ariz.

85 drones and related equipment, $2,352,177, **Radioplane,** 8000 Woodley Ave., Van Nuys, Calif.

Design, development, fabrication, and field installation of 10 kits in SD-1 drone, $45,565, **Radioplane,** 8000 Woodley Ave., Van Nuys, Calif.

U.S. Army Engineer Div., New England, Corps of Engineers, Portland Area, P.O. Box 977, Portland, Me.

Construction of missile facility, Bangor, Me., $8,684,862, **John A. Volpe Construction Co., Inc.,** 54 Enstern Ave., Malden, Mass.

U.S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Design of hypersonic wind tunnel, $26,661, **Sandberg-Serrell Corp.,** 1274 E. Colorado St., Pasadena, Calif.

Engineering research and development relating to guided missiles, free rockets, materials, and wind tunnel operation, $4,868,295, **Cal Tech,** 1201 E. California St., Pasadena, Calif.

Lox tank computer, $49,875, **Wallace O. Leonard,** 373 S. Fair Oaks Ave., Pasadena, Calif.

Furnishing and delivering of depot replenishment repair parts for Corporal missile system, $1,369,872, **Gilfillan Bros. Inc.,** 1815 Venice Blvd., Los Angeles 6, Calif.

Surface-to-surface guided missile, $129,750, **Firestone Tire & Rubber Co.,** 2525 Firestone Blvd., Los Angeles 54, Calif.

Honest John improvement program, $79,203, **Douglas Aircraft,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Repair parts for Nike system, $449,174, **Douglas Aircraft,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Pump, vacuum, lox tank, equipment installation, $46,949, **Douglas Aircraft,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Dart antitank guided missile, $1,498,139, **Aerophysics Development Corp.**, P.O. Box 689, Santa Barbara, Calif.

Telemetry system, $188,317, **Telemetering Corp. of America,** 8345 Hayvenhurst Ave., Sepulveda, Calif.

Supplies and services relative to missile targets, $47,154, **Radioplane Co.**, 8000 Woodley Ave., Van Nuys, Calif.

Nike warheads and fuzes, $816,862, **Rheem Mfg. Co.**, 9236 East Hall Rd., Downey, Calif.

Hypersonic research, $80,000, **Cal Tech**, 1201 E. California St., Pasadena, Calif.

Rocket engines, $1,331,454, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

Material testing relative to plasma jets, $158,575, **Giannini Research Corp.**, 18400 S Main St., Santa Ana, Calif.

Replenishment repair parts for guided missile and related ground handling equipment, $472,833, **Firestone Tire & Rubber Co.**, 2525 Firestone Blvd., Los Angeles 54, Calif.

U.S. Army Ordnance Missile Command, Redstone Arsenal, Ala.

Jato units, $25,177, **Packard Mfg. Co.**, 115 W. College Ave., Indianapolis 7, Ind.

Continuation of R&D work on solid-propellant engines for large rockets to provide for concentration of effort, $304,882, **Thiokol Chemical Corp.**, Trenton, N.J.

U.S. Army Signal Supply Agency, 225 S. 18 St., Phila. 3, Pa.

Additional research work on missile tracking antenna systems, $65,518, **Stanford Research Institute**, Menlo Park, Calif.

Rocket motors, window darts, pyrotechnic fuze, $27,003, **Cooper Development Corp.**, Monrovia, Calif.

AIR FORCE

AF Cambridge Research Center, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Mass.

Research on radiation and reception of electromagnetic energy from aircraft and guided missiles, $99,110, **Stanford Research Institute,** Menlo Park, Calif.

Instrumentation to measure composition of the atmosphere at altitudes around 300 miles, $54,971, **Bendix Aviation Corp.**, Research Laboratories Div., P.O. Box 5115, Detroit, Mich.

Design, develop, and construct a modified Bendix model 15-100 spectrometer adapted for rocket installation, $61,922, **Bendix Aviation Corp.**, Research Laboratories Div., P.O. Box 5115, Detroit, Mich.

Design and construct a rocket-borne monochromatic camera, $32,917, **Ball Bros. Research Corp.**, Boulder, Colo.

Research directed toward study of planetary atmospheres, $35,270, **Harvard College,** Cambridge, Mass.

Studies on planetary atmospheres and lunar surfaces, $61,000, **Univ. of Chicago,** 5801 Ellis Ave., Chicago, Ill.

AF Flight Test Center, ARDC, USAF, Edwards AFB, Calif.

Study of high-altitude test diffuser, $57,090, **Sandberg-Serrell Corp.**, 1276 E. Colorado St., Pasadena, Calif.

AF Missile Development Center, ARDC, USAF, Holloman AFB, N. Mex.

Support services and parts for tests of human tolerance to supersonic windblast, $69,068, **Northrop Aircraft,** Hawthorne, Calif.

Modification of balloon capsule system and Manhigh III flight, $99,600, **Winzen Research, Inc.**, 8401 Lyndale Ave., S., Minneapolis 20, Minn.

Shake electromagnetic vibration system for use by the Stratospheric Branch High Altitude Test Div., $89,665, **MB Mfg. Co.**, P.O. Box 1825, New Haven 8, Conn.

Study of alkali metals as propellants, $31,127, **Arthur D. Little, Inc.**, 30 Memorial Drive, Cambridge, Mass.

Ogden Air Materiel Area, USAF, Hill AFB, Utah.

Rocket mission evaluators, $503,601, **Northrop Aircraft,** Hawthorne, Calif.

Kit, spare parts for Rascal guidance operator trainer, $54,036, Special **Bell Aircraft,** Special Weapons Div., P.O. Box 1, Buffalo 5, N.Y.

Topeka AF Depot, USAF, Topeka AF Station, Topeka, Kans.

Test stand, $153,086, **Walter Kidde & Co., Inc.**, 675 Main St., Bellville 9, N.J.

Test stand, $139,680, **Merz Engineering Co.**, 200 S. Harding St., Indianapolis 7, Ind.

NAVY

Dept. of the Navy, Bureau of Aeronautics, Washington 25, D.C.

Prepare and furnish preliminary report covering design, specifications, weight, and performance of nuclear propulsion systems and suitability of specific aircraft nuclear propulsion systems for application to military missions, $374,500, **United Aircraft Corp.**, E. Hartford, Conn.

Dept. of the Navy, Office of Naval Research, Washington 25, D.C.

Research and survey of operational environment factors which effect crew efficiency in Polaris weapons systems, $25,168, **Dunlap and Associates, Inc.**, Stamford, Conn.

District Public Works Office, First Naval Dist., 495 Summer St., Boston 10, Mass.

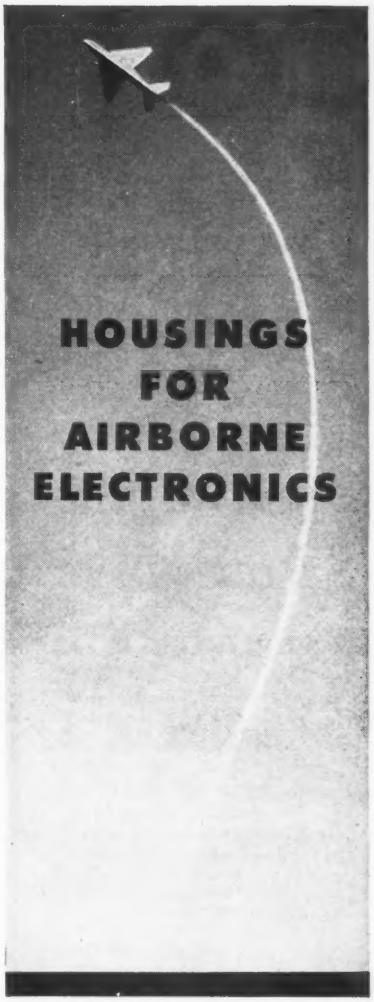
Guided missile support facility, U.S. Naval Ammunition Depot, Hingham, Mass., $209,990, **Boston Bldg. & Construction Corp.**, 534 Beacon St., Boston 15, Mass.

Navy Dept., Bureau of Ordnance, Washington, D.C.

Engineering services in connection with maintenance, overhaul, alteration, and solving of industrial processes of guns, mounts, and missile launchers, $75,000, **Universal Match Corp.**, Armament Div., St. Louis 21, Mo.

Puget Sound Naval Shipyard, Bremerton, Wash.

Spare parts for missile launching system, $27,847, **United Products Co.**, Div. of Meridan Corp., 3001 N. Starr St., Tacoma 2, Wash.



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Supporting Research

(CONTINUED FROM PAGE 25)

possibilities were recognized at the outset to include both radio and inertial techniques. Taking up those problems connected with the radio art, one has first of all the question of accuracy of radio propagation in the troposphere.

A program was first initiated at R-W to investigate performance figures on known systems which approached the required accuracy. At the same time, a study was initiated to derive theoretical limits on the accuracy of propagation in the troposphere.

Although these studies showed that accuracies required of the radio elements of a radio-inertial guidance system were within the limits attainable by practical systems, the following questions arose: What are the actual limits over all conditions? And, could one expect actual practical equipment to meet the system requirements?

To answer the questions, a program was activated using the facilities of the National Bureau of Standards, the University of Texas, AF Cambridge Research Center and Wright Air Development Center, all leaders in the field of tropospheric propagation research. The general philosophy used in designing the experiments was to provide as direct a simulation of candidate guidance systems as was reasonably possible, while still retaining enough flexibility to provide answers over a wide range of possible parameters. The experiments were also designed to give results of general scientific interest, but this was always a secondary consideration, the main objective being to allow certain system decisions to be made.

The experiments themselves were divided into two groups. The first of these, a more or less direct simulation of the guidance equipment, was conducted by NBS and Texas U. A transmitter was placed on a high mountain top and spaced receivers spotted near the base of the mountain. A wide variety of baseline lengths was used and substantially the same experiment performed over several different paths. Different wavelengths were also used to check the theoretically predicted lack of wavelength dependence. Studies of the literature had suggested, but by no means proved, that weather effects might be an important factor in determining the level of atmospheric noise. The original mountain sites chosen were in Colorado, and after some experience it was evident that, while weather was indeed a factor, in general, conditions for maximum atmospheric effect were very seldom found on the sites chosen. Accordingly, a climate study was undertaken and another site (Mt. Haleakala) picked where the expected weather effects could be anticipated on a fairly regular basis.

At the same time these line-of-sight measurements were being run, AF CRC and WADC were asked to help in a program of measurement of the troposphere by the use of airborne refractometers. These agencies already had instrumented aircraft which were being used for other investigations of a related nature. Aircraft measurements were made in several parts of the country, and these were extremely helpful in determining weather effects.

The program has resulted in improved knowledge of the characteristics of the troposphere for line-of-sight propagation. These measurements give, in fact, the ultimate limiting accuracy of radar or radio location systems operating from the surface of the earth.

Ionospheric Noise

A closely connected program involves the investigation of radio propagation in the ionosphere. The fact that the ionosphere induces noise on radio waves propagated through it has been known for many years. However, the exact amount of this noise and its variation with the frequency of the wave were not too well known. In particular, the characteristics of the phenomenon known as sporadic E are still quite mysterious, although enough was known to make us suspect that one of the principal periods of line-of-sight instability would be those times when sporadic E was present. After considerable analysis and study of various experimental programs, it was decided that the most useful research program here would again be one which provided the most direct analogy with proposed guidance systems.

The NBS Ionospheric Physics Section has been selected to conduct this program, which centers on experiments involving the tracking of one of the more intense radio stars with a fixed base interferometer. The experiment uses some standard techniques of radio astronomy but incorporates certain innovations. One is the obtaining of a precise frequency scaling law. Another is the use of continuous tracking of the star in place of intermittent measurement of position common in many previous experiments of this nature.

An auxiliary investigation, the so-called fading origin experiment, was suggested by NBS. While this new experiment was tailored originally to

the needs of our specific guidance requirements, it is producing results of quite general scientific interest.

A third problem connected with radio transmission is transmission of guidance data links and telemetry signals through the rocket motor flame. A semi-empirical program was initiated and theoretical studies were begun. The nature of the program was such that direct measurement of the quantities desired was difficult. Attenuation through the flame depends strongly on the shape of the flame, its density and temperature, and the constituent gases. Rocket motor tests at sea level do not give flame shapes at all representative of those at extreme altitudes, where the effects would be most serious.

A method of handling this problem based on a mixture of empirical measurements and theoretical extrapolation was evolved at R-W and necessary measurements undertaken by the Naval Research Laboratory, Experiment Incorporated, Rocketdyne, and Sylvania Electric Products. Stanford Research Institute (as well as Bell Telephone Laboratories and Applied Physics Laboratory, Johns Hopkins University, for short intervals of time) made measurements on full-scale motors at sea level with the assistance of Rocketdyne. These measurements have determined attenuation by means of microwave transmission loss measurement.

Experiment Incorporated embarked on a program to measure an electron concentration in the exhaust gases by the use of a Langmuir probe technique. This program was initiated as a check on the microwave measurement. Theoretical work at R-W has shown that the usual theory of microwave attenuation is not necessarily correct when applied to rocket gases; some independent means of measuring electron density was desired.

Inertial Component R&D

In addition to basic knowledge regarding radio propagation and flame attenuation, the success of a combination radio-and-inertial guidance system depends, as does that of an all-inertial guidance system, upon a firm foundation of research and development in the field of inertial components. The Instrumentation Laboratory at MIT has been engaged in research and development in this area for many years. Many of the ideas employed by industrial organizations in the past and present are a result of the MIT work.

The continuing MIT R&D effort in support of the AF ballistic missile problems consists of: (1) Design and construction of improved gyroscopes, accelerometers, and inertial platforms to be used in the evaluation of inertial systems under various environmental and flight conditions; (2) a continuing investigation of lighter weight materials and designs for inertial components and airborne computers; and (3) investigation of improved methods of testing gyros and accelerometers, and of identifying the sources and magnitudes of inaccuracies.

Another program is the development of a sled test facility to check the accuracy of existing and improved inertial components under environmental conditions similar to those found in missile flight. The liquid-rocket propelled sled was developed by Aerojet-General Corp. for use on the supersonic track at NOTS. To be useful for this type of precision work, it was necessary to develop a highly accurate system for external measurement of sled velocity. This facility is being used primarily by Arma and AC Spark Plug to check the accuracy and performance of components and complete guidance systems.

The use of a rocket sled is very attractive from a standpoint of economy in that it provides a relatively inexpensive means of testing components and systems in the combined environment of complex vibration superimposed on steady state acceleration, and yet allows the systems to be completely recovered for further testing.

Investigation of the present state of knowledge of the fundamental physical constants required in connection with guidance problems was another area in which research was found necessary. To guide a ballistic missile from one point to another on the earth, one must know to a high degree of accuracy the size and shape of the earth, the value of the gravity constant, the mass and rate of rotation of the earth, the velocity of light, etc.

The present state of knowledge concerning such constants has been evaluated and, as might be expected, in some instances the value was known to an accuracy several orders of magnitude better than needed, and in others improved data were required. Measurements were initiated to bring our current knowledge of all constants up to something better than actually needed. In this way, there is a margin of accuracy which may be used for better evaluation of test results.

The problem of successful re-entry probably represents the greatest state-of-the-art advancement embodied in the long-range ballistic missile program. The velocity characteristics of ballistic missile re-entry, even for moderate ranges, are such that they exceed by a large margin the domain of aerodynamics as it was known a

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few years ago. Such usual problems as boundary layer heating, both laminar and turbulent, and boundary layer transition, are greatly complicated by the conditions of re-entry, which produce, for example, very large temperatures involved, cause the air to dissociate.

In addition, problems new to engineering aeronautics were introduced by these extremely high velocities. The radiation from "air" as a source of heat, the thermodynamic properties of "air" at these extreme conditions, the flow field (i.e., velocity and pressure distributions about various shapes) were not well known, and many other problems of similar nature were encountered.

While theoretical analysis of such problems was carried out in earlier years, it was necessary in most cases to extend or modify this work to make it applicable to re-entry conditions. Intensive analytical effort was directed toward the outstanding problems and resulted, in all cases, in allowing engineering design of re-entry bodies to proceed. Most of the analytical studies were undertaken by nose cone contractors (Avco and General Electric), by NACA and R-W itself. Significant contributions were made by other groups and by individual consultants to the foregoing organizations.

However, in view of the importance of the re-entry problem to the ballistic missile programs, it was essential to obtain experimental verification of the analytical work upon which the solutions to re-entry rested. A few groups, notably the NACA laboratories, were working on very high-speed research problems and facilities but, because of the acceleration of the ballistic missile programs, it was necessary to initiate very active research programs directed toward specific re-entry needs.

Additional Programs Initiated

Accordingly, two additional major experimental activities were initiated. These were the Avco shock tube program and the Lockheed Aircraft Corp. re-entry test vehicle flight program.

The Avco program consists of a facility which embodies several shock tubes ranging in size up to one 100 ft long and 4 in. in internal diam. Some of the important details in measurement techniques and data interpretation, etc., were strongly influenced by previous work done at Cornell Aeronautical Laboratory and Princeton University.

Although sufficient for certain purposes, shock tube test times are quite short and, in a straight tube, Mach numbers attainable are relatively low. However, the program has provided a very considerable body of information on laminar and turbulent boundary layer heating under the conditions of re-entry—that is, with very large temperature differentials and dissociated air. Test data on aerodynamic heating so far obtained have corroborated the analytical work which preceded them. In addition to the data on convective heating, data have been obtained on radiative heating from air at temperatures and pressures encountered during re-entry. Data on many other problems, such as propagation of electromagnetic radiation through ionized air, recombination rates of dissociated air, etc., have also been obtained.

The Avco shock tube program represented an approach to the ICBM re-entry experimental problem which could be carried out by the extension of techniques which were relatively well known and had the virtue of using a ground facility. While this met many of the needs of the problem, it could not meet all of them.

It was therefore also necessary to investigate in flight such phenomena as boundary layer transition, a fundamental parameter of re-entry. A flight

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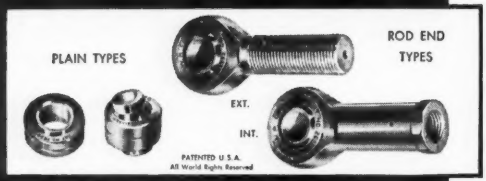

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research vehicle development program was assigned to Lookheed to permit investigation of phenomena pertinent to re-entry.

The missile selected was a three-stage, solid-propellant rocket approximately 40 ft in length. In operation, the first stage boosts the vehicle to a velocity sufficient to allow it to attain very high altitudes and, after the missile has re-entered the atmosphere, the second and third stages further accelerate the test body, which can be a scaled model of a nose cone. Reynolds numbers and maximum velocities are sufficiently large to be directly applicable to re-entry body design.

Re-entry data research flights have been underway for many months, and extremely significant data have been obtained. Data on boundary layer transition have been of particular significance, but data have also been obtained on laminar and turbulent boundary layer heating, electromagnetic propagation attentuation, effects of surface roughness on boundary layers, pressure distribution at high velocities, etc.

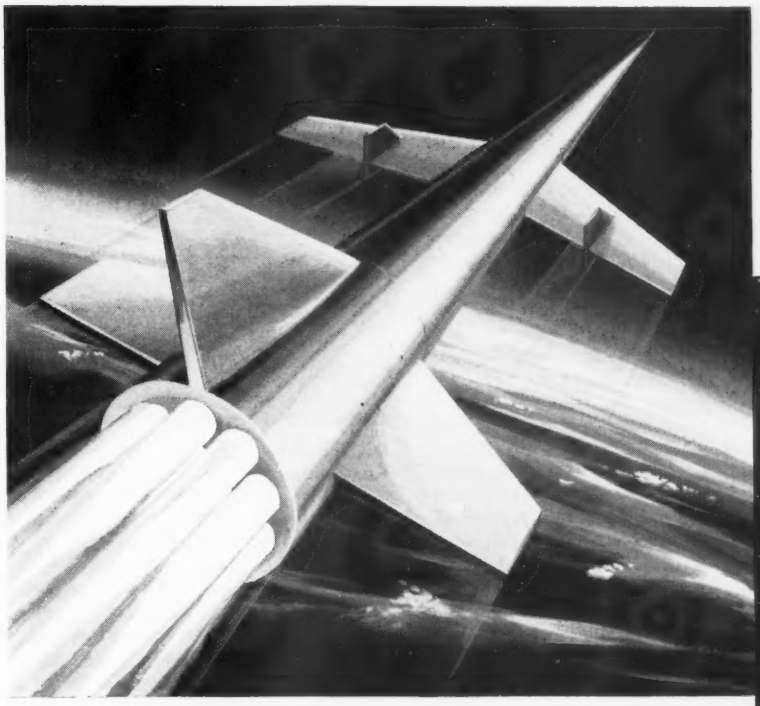
Where they are comparable, it is interesting to note that RTV and shock tube data correlate quite well.

In summary, we now have a reasonably complete analytical knowledge of re-entry problems and have corroborated analytical results with certain basic experimental data. The full-scale flight tests are, of course, a source of fundamental re-entry data but, if for no other reason than the cost of such testing, a well-balanced program of basic research on hypersonics problems can be expected to continue indefinitely. It is also necessary to continue the analytical studies of all facets of re-entry and, where appropriate and necessary, to perform definite experimental studies.

It is obvious from the above that a research program has been a necessary adjunct of the AF ballistic missile program. It has not only paid high dividends in providing needed information and broadening our knowledge, but has also led to great savings in time and money in one of the most important programs ever undertaken in this country.

BIS Plans Space Biology Symposium in October

The British Interplanetary Society is in the process of organizing an international symposium on space biology, to be held in London early in October of this year. While the actual dates have not as yet been announced, it is hoped to arrange the dates to coincide with the 25th anniversary of the founding of the Society.



Engineers—Scientists

The Bell Aircraft *Rockets Division* forges ahead with new types of rocket engines and propellents to provide the higher thrust and greater efficiency needed to push missiles, satellites and manned space vehicles through the earth's atmosphere into outer space.

These programs are the outgrowth of over a decade of Bell experience in rocketry, beginning with the record-breaking X-1 and X-2 supersonic rocket-powered aircraft, and continuing with the development of rocket power plants for projects like the Rascal air-to-surface missile.

Continued growth and expansion in the *Rockets Division* have opened a number of select positions in the following fields:

Propulsion Systems Development
Combustion and Fuels Research
Systems Installation
Structural Analysis
Instrumentation
Rotating Machinery
Controls Development
Laboratory Testing

To learn more about the personal opportunities and unexcelled benefits now available to you as a member of our Rockets Division engineering team, send resume of your qualifications to: Supervisor of Engineering Employment, Dept. Y-32, Bell Aircraft Corporation, P. O. Box One, Buffalo 5, New York.

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New equipment and processes

Digital Voltmeters Set New Standards of Accuracy, Speed

The traditional analog voltmeter with familiar dial and needle no longer meets many needs for accuracy and speed in the aircraft and missile industry. Even in the laboratory, the analog voltmeter measures true to only 0.5 per cent of full scale, and the attainment of this accuracy is hampered by parallax angles and difficulty in interpreting the scale, especially when voltage fluctuates rapidly. Analog voltmeters require pre-knowledge of polarity and range of measurement; and even a skilled technician sometimes mistakes settings, which loses time and can lend to voltmeter damage. Instruments to digitalize analog information now increase the speed of making readings greatly and eliminate errors of judgment in reading scale.

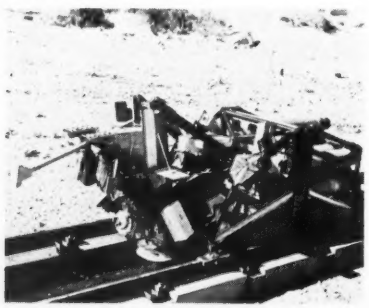
A digital voltmeter of the kind shown here, originated by Non-Linear Systems, Inc., Del Mar, Calif., operates on the principle of the self-balancing digital potentiometer, which,

Digital voltmeters, like this one by Non-Linear Systems, Inc., give nominal error of only 0.03 per cent of measured voltage.

to measure an unknown input, sets up a known reference voltage equal or proportional to the unknown. Rotary stepping switches allow rapid movement from value to value in a voltage-divider network, and stop when the potentiometer circuit balances unknown and reference voltages, causing lucite numeral points to show a readout corresponding to the balance voltage. Signals to actuate recorders and other devices can be manipulated in a similar way. The instrument gives polarity; and it attenuates automatically on over-voltage, which in turn allows automatic range switching and correct placing of the decimal point.

Digital voltmeters make possible a nominal overall error of only 0.03 per cent of measured voltage; and because the instruments can be linked with automatic readout devices, there is no need for highly skilled technicians to obtain accurate voltage data. The accuracy and sensitivity of the instruments makes them adaptable to measuring systems based on low-energy transducers—for instance, for direct readings, without amplifiers, of strain gages and thermocouples. Tied into automatic "go-no-go" test equipment, they can control automatic production processes or furnish printed sequential records of electrical values in a process.

High Speed Camera



Rocket sled equipped with four Fastair cameras to record seat ejection action.

The Fastair camera was designed by Wollensak Optical Co. to meet the needs of leading missile and airplane manufacturers for a high-speed motion picture camera which would take pictures when mounted in test missiles or vehicles accelerating to high rates of speed in short increments of time.

Basic design specifications required that the camera operate when subjected to g loads in acceleration or deceleration up to 100 times the force of gravity at almost any altitude, that it fit in a space 4 by 4 by 14 in. and weigh not more than $8\frac{1}{2}$ lb. It was required to operate at from 12 to 600 frames per sec, have a timing light, timing light pulse generator, thermostatically controlled heaters, a wide variety of interchangeable lenses, a flat speed characteristic curve, be capable of "stop-start" operation, and accept standard daylight loading film spools.

•

Rate Switch: Adjustable rate switch RSO3-0101-1 makes it possible to stock rate switches and set them for the rate required in experimental projects. On recoverable vehicles, adjustments can be varied between test flights. The switch has a rate range from 10 to 200 deg per sec. Natural frequency is greater than 30 cps. Unit operates on 400-cycle, 115-v single-phase power. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

•

Density Measurement System: An AccuRay system which measures and/or controls fluid density, specific gravity, per cent solids, or related quantity is applicable to liquids, slurries, and flaked, granulated, powdered or other divided solids. Based on the principle of gamma ray transmission from a radioisotope, the system makes no physical contact with the flowing material. Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio.

Transistorized Signal Simulator: The ASCOP MSS-3 is a laboratory standard for simulating PW signals of 30x30, 45x20, 60x15, and 90x10 configurations for checking and calibrating telemetering ground stations. It is designed for use in testing of PW telemetering stations used in the aircraft and missile field, as well as for engine test stands, nuclear reactors, powerplants and similar projects. Applied Science Corp. of Princeton, P.O. Box 44, Princeton, N. J.

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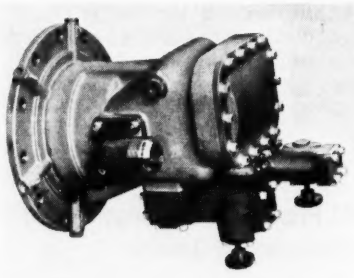


High-Pressure Hydraulic Pump: A variable delivery, variable pressure, hydraulic pump capable of pressures up to 5000 psi has been developed for missile launching and test stand applications. The pump delivers 38.2 gpm at 3750 rpm and 3000 psi. Vickers, Inc., Detroit 32, Mich.

Heat Transfer Course To Be Given Aug. 7-15

A special Heat Transfer course aimed at engineers and scientists in the aircraft, missile, and nuclear power fields is being offered by the University of Minnesota's Heat Transfer Laboratory of the Mechanical Engineering Dept., August 7 to 15. Lecturers, in addition to the laboratory staff under the direction of E. R. C. Eckert, will include Professors S. A. Schaaf, U. of Calif.; J. W. Westwater, U. of Illinois; H. S. Isbin, U. of Minnesota; C. E. Treanor, Cornell Aeronautical Laboratories; and R. Hosmer Norris, GE. Tuition will be $180.

Further information can be obtained from Dr. James P. Hartnett, Mechanical Engineering Dept., U. of Minnesota, Minneapolis 14.

ARDC Bio-Satellite Coordinating Group Meets

INGLEWOOD, CALIF.—The AF Ballistic Missile Division here played host to the ARDC Bio-Satellite Coordinating Committee in mid-April. The committee is an information exchange group set up by Lt. Col. David G. Simons, chief of the Aero Medical Field Lab, at the request of Brig. Gen. Don Flickinger of the ARDC Life Sciences Command. Its functions are (1) to provide for a complete exchange of information on bio-satellite flight; (2) to coordinate interservice interests in nonhuman bio-satellite experimentation and research; and (3) to serve as a channel of communication between various groups interested in such research.

Present at the meeting were representatives of the Naval Air Development Center, Johnsville, Pa.; the AF School of Aviation Medicine, Randolph AFB, Tex.; the Aero Medical Field Lab at the AF Missile Development Center, Holloman AFB, N. M.; and the Aero Medical Lab, Wright Air Development Center, Ohio.

Items discussed included a review of possibilities envisioned for current bio-satellite flights, a discussion of the ground facilities needed for such flights and a review of the GE proposal for capsules to be used in such flights. The academic committee, represented by Harry Harlow of the U. of Wisconsin and Robert Siecker of Duke U., presented information about biological specimens which could be used for flights of this kind.

Another meeting of the committee was held the last week in May at Johnsville. Representatives included those from the labs listed above, as well as ABMA representatives.

—Capt. G. J. D. Schock

Giant Data Processing Unit To Handle ICBM-IRBM Problems

A huge new automatic data processing system recently installed at Norton AFB, near San Bernadino, Calif., will afford quick handling of logistical problems for the Atlas and Titan ICBM's and the Thor IRBM, and will help solve problems of supply, maintenance, transportation and quality control.

Heart of the system is a general purpose digital IBM 705 computer, greatly expanded by the addition of auxiliary components. In full operation, the system keeps track of more than 100,000 different parts and assemblies, maintaining weapon systems at combat readiness.

In effect, the system links the ballistic missile manager, operating squadrons, supporting Air Materiel Command bases and ballistic missile contractors. The computer will analyze data from operational units, pass these on to the weapon system storage site, depot or contractor, as indicated, and trigger the airlift response. All transaction information will flow in minutes over transceiver networks in and out of the control location, backed up by teletype circuits. This communication system will then be connected from the center to the AMC transceiver network, and with the AF administrative teletype network, Aircomnet.

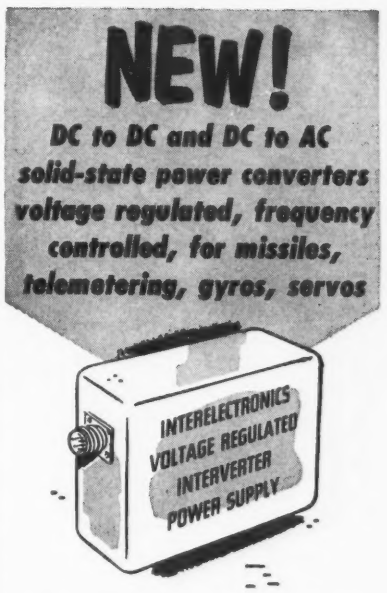
The directorate of ballistic missiles organized to support the entire program consists of Col. Philip B Foote, director of some 600 workers, reporting directly to Gen. Anderson, commander, San Bernardino Air Materiel Area and Col. Robert E. Kirby, who will report to Col. Foote, and will be in charge of 200 technicians.

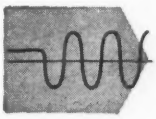
—Eric Burgess

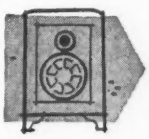
Saucers Buried?

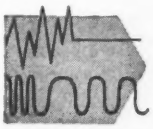
A scientific panel on Unidentified Flying Objects, convened by the Government to review evidence presented by the USAF, has concluded that these objects do not constitute a direct physical threat to national security, and recommends that national security agencies take immediate steps to reassure the public "of the total lack of evidence of inimical forces behind the phenomena."

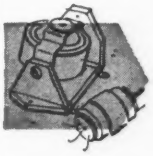
The committee was chaired by H. P. Robertson, Cal Tech. Other members were: Luis W. Alverez, University of California; Lloyd V. Berkner, Associated Universities, Inc.; S. A. Goudsmit Brookhaven National Labs.; and Thornton Page, Johns Hopkins University.











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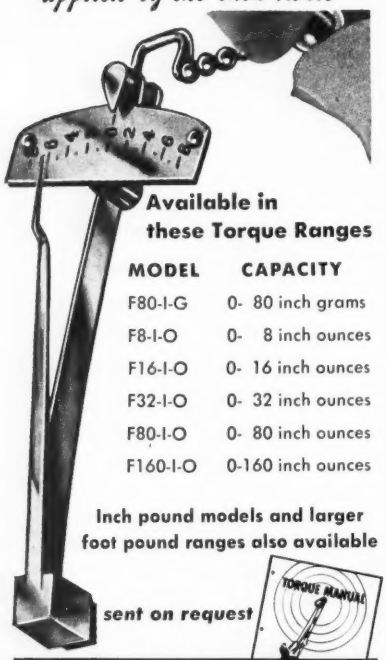

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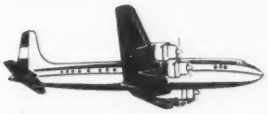

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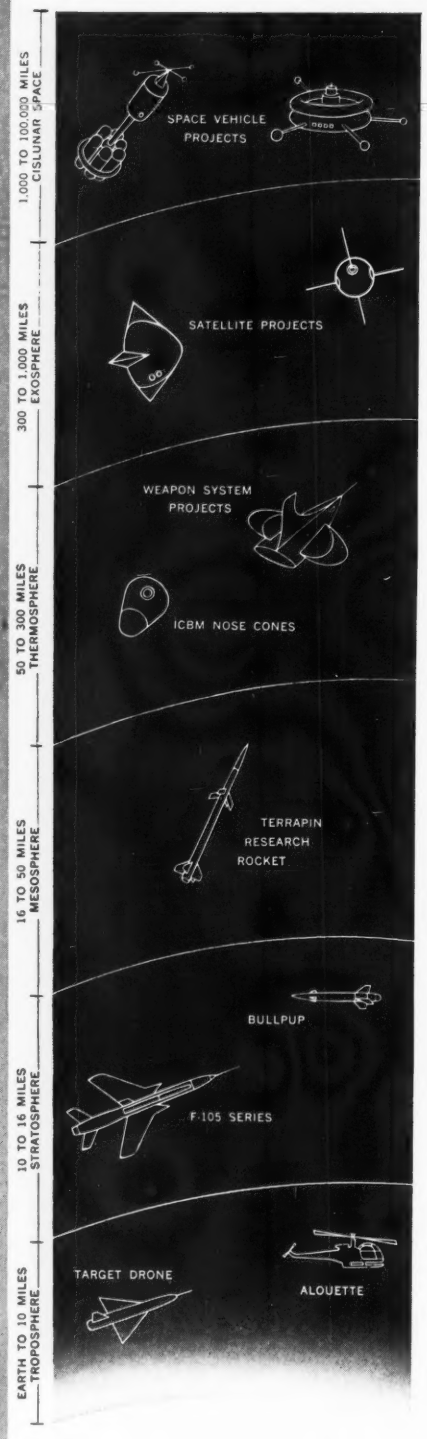

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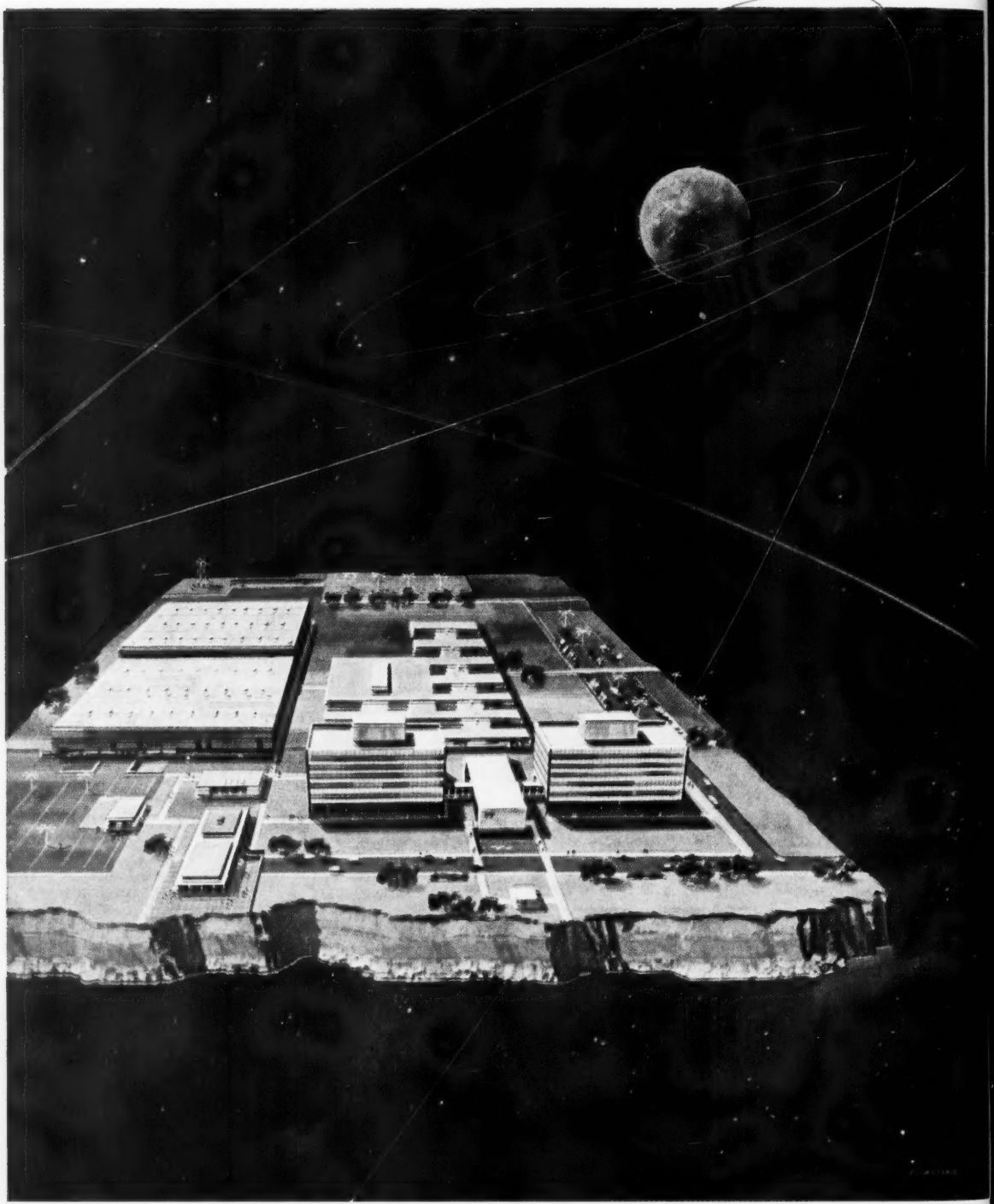

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